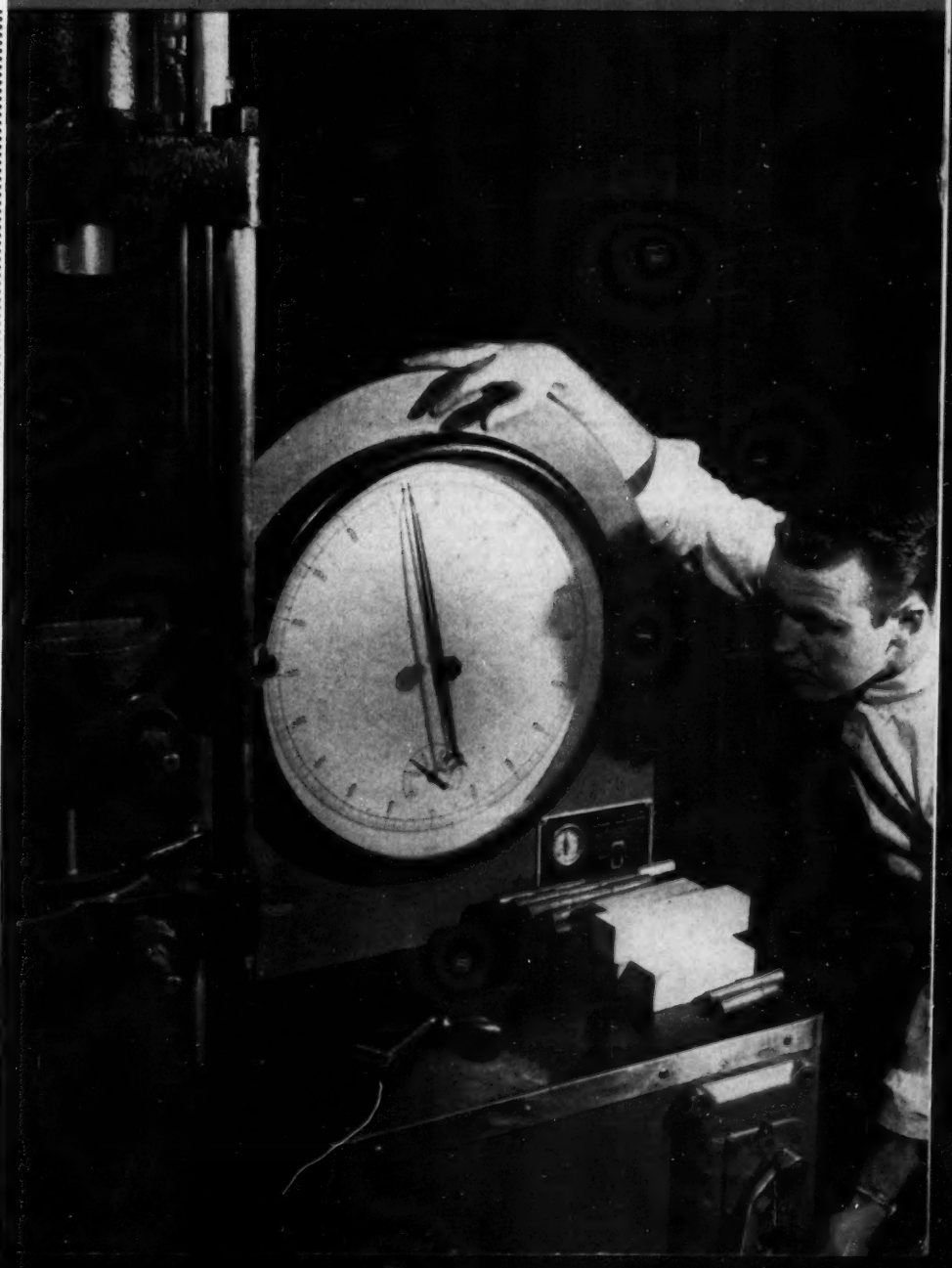
COLLEGE OF ENGINEERING CORNELL UNIVERSITY

the Cornell

engineer



MAY, 1954

VOL. 19, NO. 8

25 CENTS

Only STEEL can do so many jobs so well

They Chew Their Way to Wealth. These teeth are capable of chewing through earth, sand and rock for thousands of feet until they reach Nature's buried treasures of gas and oil. Rock bits like this need super-strength, amazing toughness, high resistance to impact, abrasion, and shock. So, many of them are made from USS Alloy Steels. And United States Steel also provides many other essentials for oil drilling, such as wire lines, drill pipe, cement, drilling rigs.

Scoop! And a big one, too . . . it can scoop out 21.5 cubic yards of earth per minute, has a boom 215 feet long! The drag lines, boom support cables and hoisting ropes on a behemoth like this must have great strength, durability, flexibility, fatigue resistance. Tiger Brand Wire Ropes, made by U.S. Steel, meet all requirements.

OPPORTUNITIES WITH U. S. STEEL

If you're thinking about what you're going to do after graduation . . . if you're interested in a challenging, rewarding position with a progressive company . . . then it will pay you to look into the opportunities with United States Steel. Your placement director can give you more details, or we'll be glad to send you the informative booklet, "Paths of Opportunity." United States Steel Corporation, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

A Man Needs a Cookie once in a while! And when cookies are kept in a tight cookie tin like this, they'll be fresh and appetizing for him. The can is steel, of course . . . made out of the same USS Tin Plate that is produced by U.S. Steel to make millions of "tin" cans every year for the protection of food, oil, paint and countless other things.

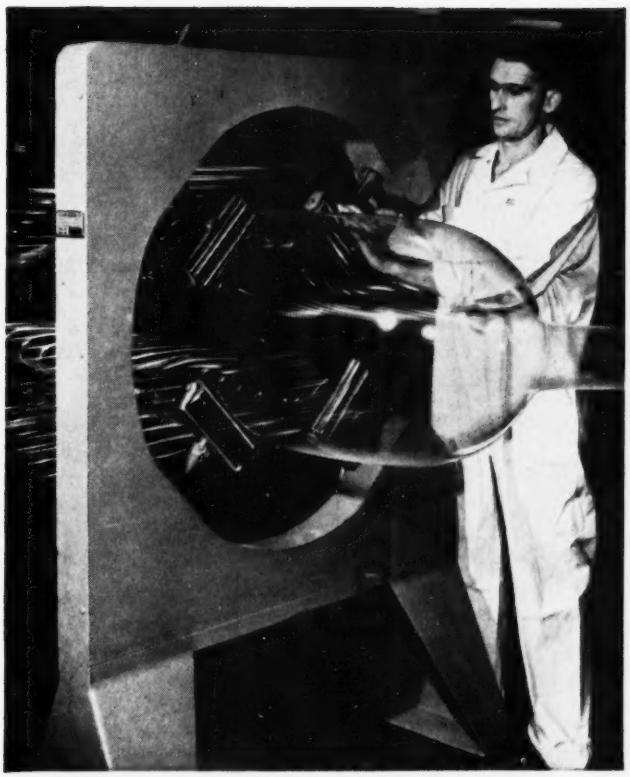
For further information on any product mentioned in this advertisement, write United States Steel, 525 William Penn Place, Pittsburgh 30, Pa.

MANUFACTURED FROM USS STEEL UNITED STATES STEEL

UNITED STATES STEEL

This trade-mark is your guide to quality steel

AMERICAN BRIDGE . . AMERICAN STEEL & WIRE and CYCLONE FENCE . . COLUMBIA-GENEVA STEEL . . CONSOLIDATED WESTERN STEEL . . GERRARD STEEL STRAPPING . . NATIONAL TUBE
OIL WELL SUPPLY . . TENNESSEE COAL & IRON . . UNITED STATES STEEL PRODUCTS . . UNITED STATES STEEL SUPPLY . . *Divisions of* UNITED STATES STEEL CORPORATION, PITTSBURGH
UNITED STATES STEEL HOMES, INC. • UNION SUPPLY COMPANY • UNITED STATES STEEL EXPORT COMPANY • UNIVERSAL ATLAS CEMENT COMPANY 4-890



One of the early steps in the production of Saran-Wrap—the "bubble" that becomes a film after being deflated in a series of rollers.

Colorful display bins are an important part of consumer sales strategy and explain the advantages of Saran-Wrap.

TAKING CHEMICALS TO MANY MARKETS...

Dow succeeds through the careful coordination of group effort in research, marketing and sales

The high consumer acceptance gained by Saran-Wrap is a current example of what happens when extensive research and production planning is followed by coordinated marketing and sales strategy in launching a new product.

This amazing new plastic food wrap is certainly a useful product—but it is much more than that. For Dow it marks another milestone in a continuing effort to move into new fields of endeavor and to increase the variety as well as the size of its operation. Well-planned and executed projects, introducing varied industrial and consumer products, have been responsible for Dow's rapid growth to a position of prominence in the chemical industry.

Whether you choose research, production or sales, you can find a challenging career with Dow. Write to Dow's Technical Employment Department today for the booklet, "Opportunities with The Dow Chemical Company"—you'll find it interesting. ***THE DOW CHEMICAL COMPANY****, Midland, Michigan.*

you can depend on DOW CHEMICALS

Spring thoughts on the subject of...

rambunctious sheepskins

AN engineering senior can hardly be blamed for feeling rambunctious now that the years of hard study are nearly over and the sheepskin's in view.

But the sheepskin comes at Commencement. Commencement means you're set to start on your career. And that's certainly worth some serious thought.

To help you decide which job to pick, you'd do well to weigh the many reasons for choosing an engineering career at General Motors—reasons like these:

- At GM, an engineer has a real chance to follow his natural bent and work in the field of his choice. That's because GM produces a variety of products — automobiles, trucks, Diesel engines, refrigerators, bombsights, just to mention a few.
- At GM, you get the chance to work closely with top engineers, sharing their knowledge and experience. That's owing to GM's decentralization: 34 manufacturing divisions, 117 plants in 57 towns and cities. Yet each division draws upon GM's vast central research laboratories.
- At GM, there's a congenial climate for the personal and professional advancement of engineers. We respect the engineering point of view, as shown by the number of key GM executives in both divisional and top management who began their careers as engineering graduates on GM drafting boards.

Naturally, all this spells genuine opportunity for the young man who has what it takes. Your College Placement Office can arrange an interview for you with our college representative. Or you can write direct to us.

GM positions now available in these fields:

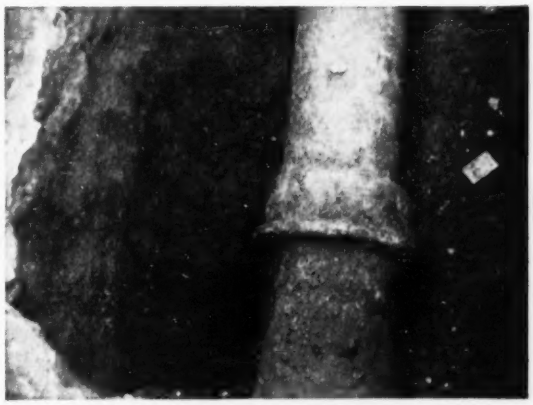
MECHANICAL ENGINEERING
ELECTRICAL ENGINEERING
METALLURGICAL ENGINEERING
INDUSTRIAL ENGINEERING
CHEMICAL ENGINEERING
BUSINESS ADMINISTRATION

GENERAL MOTORS CORPORATION

Personnel Staff, Detroit 2, Michigan

Ball-and-socket joint cast iron pipe for water main crossing river at Newark, Ohio.

Where installations are planned for long-term service to assure low cost per service year, engineers rely on cast iron pipe as a dependable and adaptable material. Consequently, it is specified for a wide variety of applications, both utility and industrial, including water supply, sewerage, fire protection, process industries and many forms of special construction. Long life and low maintenance cost are *proved* results of the high beam-strength, compressive-strength, shock-strength and effective resistance to corrosion of cast iron pipe. Cast Iron Pipe Research Association, Thos. F. Wolfe, Managing Director, 122 So. Michigan Ave., Chicago 3, Ill.



Cast iron water main still functioning in Philadelphia after 135 years of service.

CAST IRON PIPE SERVES FOR CENTURIES

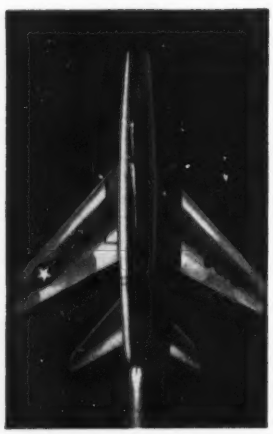
NORTH AMERICAN HAS BUILT MORE AIRPLANES THAN ANY OTHER COMPANY IN THE WORLD

MACH

BUSTER!

First of the true tri-sonic fighters, the new F-100 *Super Sabre* flies faster than the speed of sound in normal, level flight. Far advanced beyond any fighter now in production, the F-100 *Super Sabre* was designed and built by North American to meet our nation's need for aircraft with over-all weapon effectiveness—a balanced combination of productiblity... pilot safety... superior speed... fighting capacity.

With the new *Super Sabre* North American Aviation completes its 50,000th airplane... accounting for more than 1 out of every 10 airplanes built in America since the Wright Brothers first flew. If you are planning to enter the engineering profession, North American can offer you excellent career opportunities in airframe design, guided missile development, propulsion system design, electronic systems or atomic energy research and development.



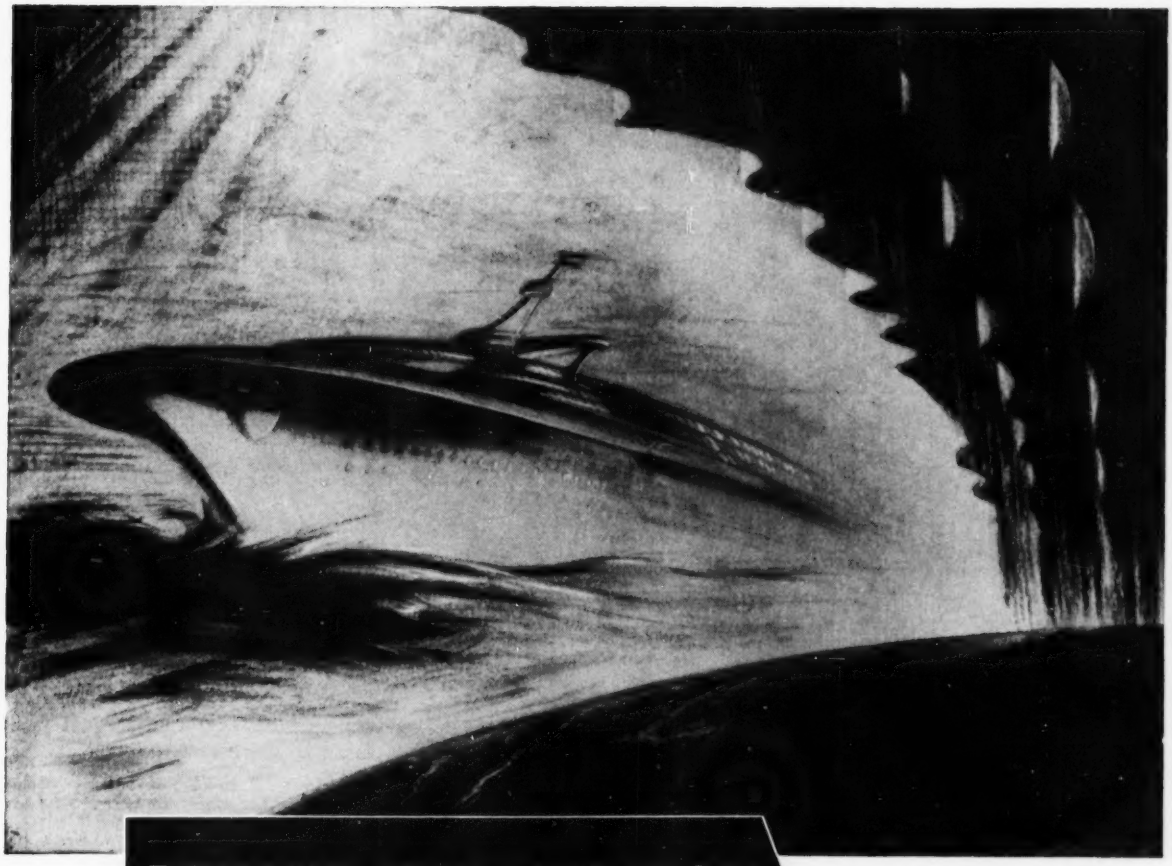
North American welcomes your inquiry concerning your future career in the aircraft industry.

Contact: Your College placement office or write:
North American Engineering Personnel Office:

International Airport, Los Angeles 45, Calif.
Columbus 6, Ohio
12214 South Lakewood Blvd., Downey, California

organization, facilities and exerience keep **North American Aviation** *years ahead*

in aircraft... guided missiles... electronics... atomic energy... research and development



BEYOND THE HORIZON....

Most of the current alloys developed for engineering use at elevated temperatures contain Molybdenum.

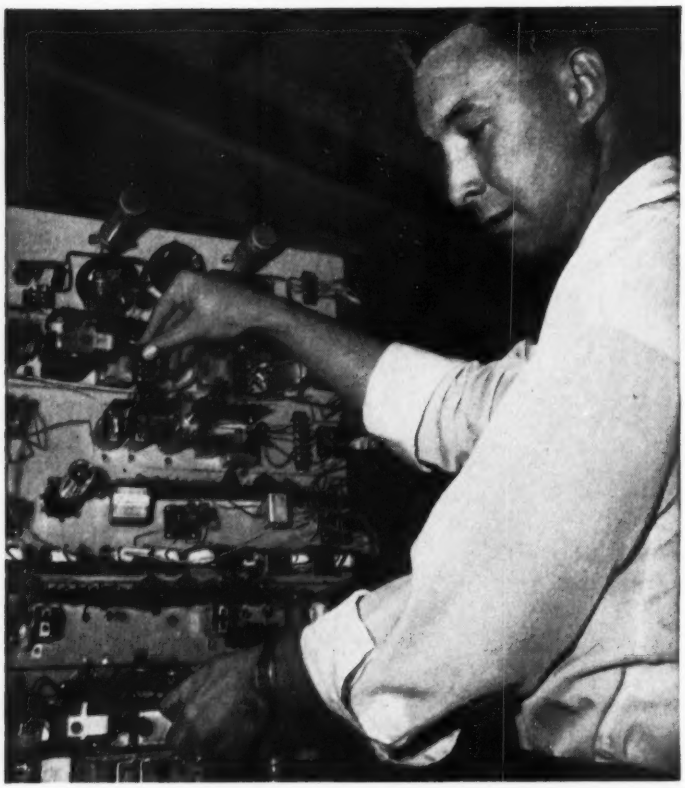
As stresses and temperatures—such as those used for marine propulsion power plants—increase, it is certain that the alloys which make this possible will rely more and more upon their Molybdenum content.

Climax furnishes authoritative engineering data on Molybdenum applications.

Climax Molybdenum Company
500 Fifth Avenue · New York City 36 · N.Y.

MOLY

A CAMPUS-TO-CAREER CASE HISTORY



Bob Wilson uses a "breadboard" circuit, studying the electrical properties of a carrier system

"My first assignment at Bell Labs"

Fresh out of school, Bob Wilson, '53, was put to work on a Transistor project at Bell Laboratories. He explains why he never had time to be awed.

(*Reading time:* 39 seconds)

"In some ways it was hard to believe. I had received my B.E.E. at the University of Delaware in June, 1953, and a week later I was working in the world-famous Bell Laboratories.

"But I didn't have time to be awed because they put me right to work. They gave me responsibility fast.

"My group was working on the experimental application of transistors to carrier systems. My assignment was the electrical design of a variolosser for the compressor and for the expandor to be located in the terminals.

"The supervision I received and the equipment I had were tops. I quickly discovered that I had to rely on my ingenuity as much as on the college courses I had taken. Perhaps that's one reason for the great new discoveries continually turned out by the Labs.

"Now I'm in the Communication Development Training Program, continuing my technical education and learning what all the Laboratories sections do and how their work is integrated.

"In a year I'll be back working with the group with which I started."

• • •

Assuming responsibility fast is a common experience among the engineering, physical science, arts and social science, and business administration graduates who join the Bell System. Bob Wilson went with Bell Laboratories. There also are job opportunities with the operating telephone companies, Western Electric and Sandia Corporation.

BELL TELEPHONE SYSTEM

John F. Schmutz — ChemE '55
editor-in-chief

Edwin A. Leventhal — Ep '56
managing editor

Milton Cherkasky — ME '55
business manager

◇

Publication Board

Lavonne C. Olson — ChemE '57
assistant editor

Thomas C. Reed — ME '56
associate editor

Evan M. Zelin — EE '57
illustrations editor

William C. Thurber — MetE '55
treasurer

Francis B. DeGress — ME '57
circulation manager

Leonard Pisnoy — CE '57
advertising manager

George Haunalter — CE '57
publicity manager

Yale Brazel — EE '56
office manager

Founded 1885

THE CORNELL engineer

MAY, 1954 VOLUME 19 NUMBER 8

Editorial Board

D. G. Douglas — CE '56
R. H. Kantor — EP '57
J. Max — EP '57
F. J. Rosengarten — ChemE '57
J. F. Ahearne — EP '57
A. H. Vaughan — EP '57
R. Brandenburg — EP '58

◇

Business Board

J. L. Beckel — Arch '56
R. K. Fisher — ChemE '57
I. M. Jacobs — EE '56
M. D. Payson — ME '58
A. P. Perlman — CE '58

◇

Illustrations Board

D. Ball — CE '55
S. G. W. Beck — EE '56
D. Crook — Arch '56
R. C. Noyes — ME '55
R. L. Simon — EE '54
D. R. Schudel — ME '57
M. C. Starr — EP '57
J. B. Shields — Arts '58

◇

Advisory Board

Dean S. C. Hollister

Technical Advisers

Prof. W. H. Erickson
Prof. J. E. Hedrick

School Directors

Prof. C. R. Burrows — EE
Prof. N. A. Christensen — CE
Prof. F. H. Rhodes — ChemE
Prof. L. P. Smith — EP
Prof. H. J. Loberg — ME

Alumni

H. H. Williams, Jr. — C.E. '26
W. H. Hill — M.E. '22

Underwater Metallic Arc Welding 11
by Roger C. Waugh, MetE '54
and Otto P. Eberlein, MetE '54

Synthetic Gems 15
by Lavonne Olson, ChemE '57

Engineers in Civil Defense—II 18
by Howard C. Young, ME '19

In Memoriam—Prof. Walter R. Jones 22

Brain Teasers 24

Engineers Day—Picture Brief 28

President's Page 30

Alumni Engineers 31

College News 34

Technibriefs 42

Chemical Engineers—Class of 1954 50

Engineering Physics—Class of 1954 50

Stress and Strain 55

Index to Volume 19 56

Member of The Engineering College Magazines Associated

Chairman: Prof. Thos. Farrell, State University of Iowa, Iowa City, Iowa
Publishers' Representative, Littell-Murray-Barnhill, Inc.
101 Park Ave., New York and 605 N. Michigan Ave., Chicago

Published monthly—October to May—by the CORNELL ENGINEER, Inc., Lincoln Hall, Ithaca, N. Y. Edited by the undergraduates of the College of Engineering, Cornell University. Entered as second class matter at the Post Office at Ithaca, N. Y., under Section 103, Act of October 3, 1917.

Subscription per year: regular $2.00; with membership in the Cornell Society of Engineers $3.00 (See President's page); student $1.50; single copy $.25.

"Allis-Chalmers Graduate Training Course Was Just What I Needed."

says LOWELL E. ACKMANN

University of Illinois—B.S., E.E.—1944
and now manager, Peoria, Ill., Branch Office

"MY EXPERIENCE with machinery in the Navy during the war convinced me I needed a training course. There was so much equipment on board that was a complete mystery to me that I became very 'training-course minded'.

"After investigating many training courses, the one at Allis-Chalmers looked best to me then—and still does.

"In my opinion, the variety of equipment is what makes Allis-Chalmers such a good training spot.

"No matter what industry you may be interested in, Allis-Chalmers makes important, specialized equipment for that industry. Electric power, steel, cement, paper, rock products, and flour milling industries—to name a few, are big users of A-C equipment.

"Before starting on the Allis-Chalmers Graduate Training Course, I thought I would like selling, preferably technical selling but, as is often the case, I didn't know for sure. This course, together with some personal guidance, helped me make up my mind. That, too, is an important advantage of the GTC program.

"But whether you want to be a salesman or designer, production engineer, or research engineer, Allis-Chalmers, with its wide variety of equipment and jobs, is an ideal place to get off to a good start—without wasting time."

Facts You Should Know About the Allis-Chalmers Graduate Training Course

1. It's well established, having been started in 1904. A large percentage of the management group are graduates of the course.

2. The course offers a maximum of 24 months' training. Length and type of training is individually planned.

3. The graduate engineer may choose the kind of work he wants to do: design, engineering, research, production, sales, erection, service, etc.

4. He may choose the kind of power, processing, specialized equipment or industrial apparatus with which he will work, such as: steam or hydraulic, turbo-generators, circuit breakers, unit substations, transformers, motors, control, pumps, kilns, coolers, rod and ball mills, crushers, vibrating screens, rectifiers, induction and dielectric heaters, grain mills, sifters, etc.

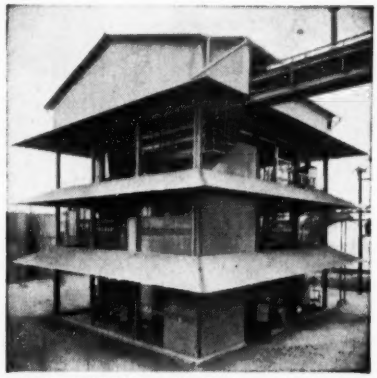
5. He will have individual attention and guidance in working out his training program.

6. The program has as its objective the right job for the right man. As he gets experience in different training locations he can alter his course of training to match changing interests.

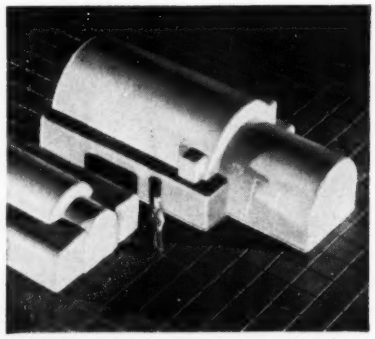
7. For information watch for the Allis-Chalmers representative visiting your campus, or call an Allis-Chalmers district office, or write Graduate Training Section, Allis-Chalmers, Milwaukee 1, Wisconsin.

ALLIS-CHALMERS

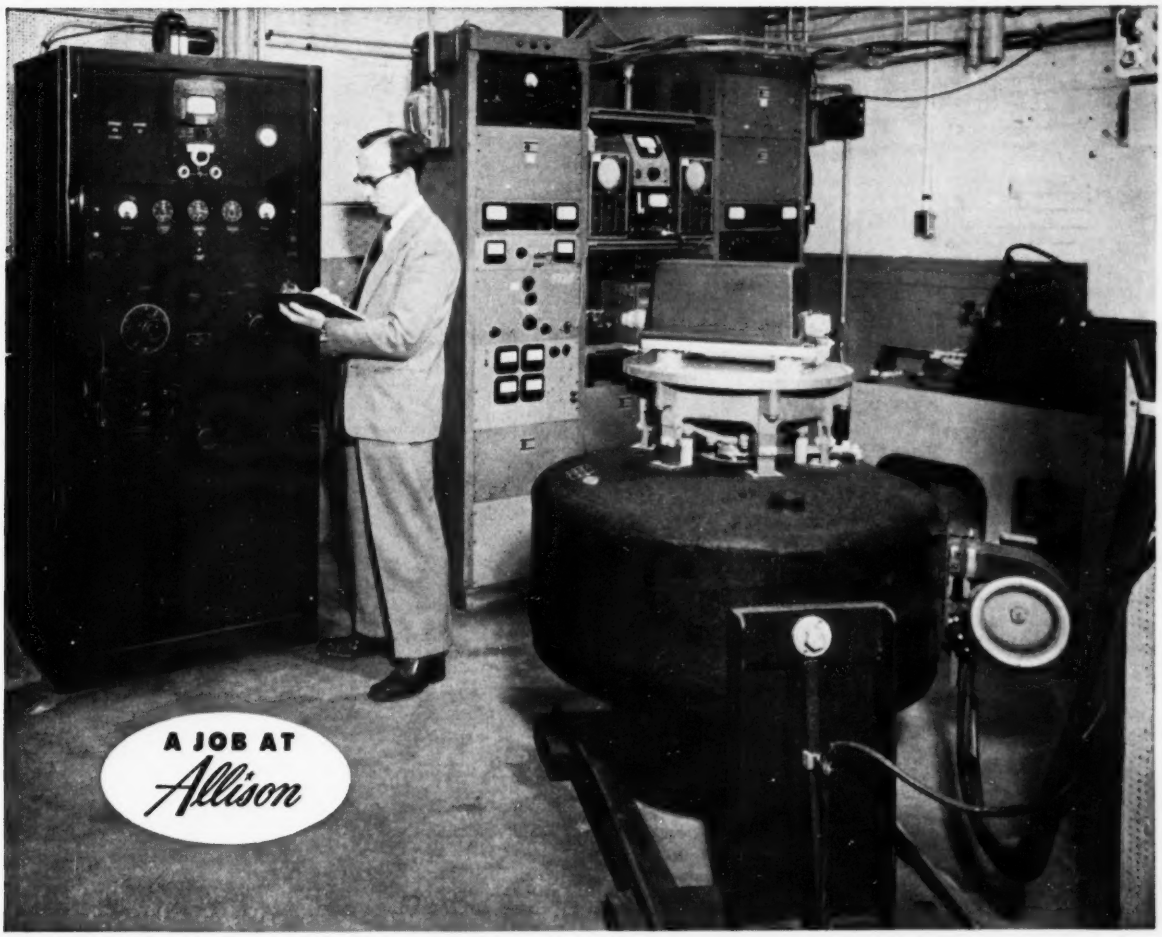
C-5676



PROCESSING—Allis-Chalmers built solvent extraction plant processes one hundred tons of rice bran per day at oil processing plant in Texas.



POWER—Models show comparative size of generators having the same rating with and without super-charged hydrogen cooling. Allis-Chalmers is first to supply super-charged hydrogen cooling.



● Cort Kegley received his Masters Degree in Physics from Connecticut Wesleyan in 1951.

When the above picture was taken he had been on the job less than a month, and was one of a group of young graduates then in training at Allison.

Much of the experimental and test equipment at Allison is entirely different from any other. And, Cort—like other new engineers on the job—must first learn about these various facilities which he will be using in instrumentation and testing.

He is pictured here getting acquainted, so to speak, with some of the equipment used in vibration and shock qualification testing. One of the many electronic accessory units used with the Allison jet engines is here undergoing a "shake test" on the large MB vibration exciter shown in the foreground.

A turbo-propeller governor is bolted to the shake table of the exciter, which is controlled from the panel at the left, to determine if simulated engine vibration will cause the unit to malfunction. The large MB exciter has the capacity to exert a vibratory force of 2500 pounds, with a frequency range up to 500 CPS. A smaller MB exciter, shown on the bench in the background, is rated at 50 pounds peak force available to 2000 CPS.

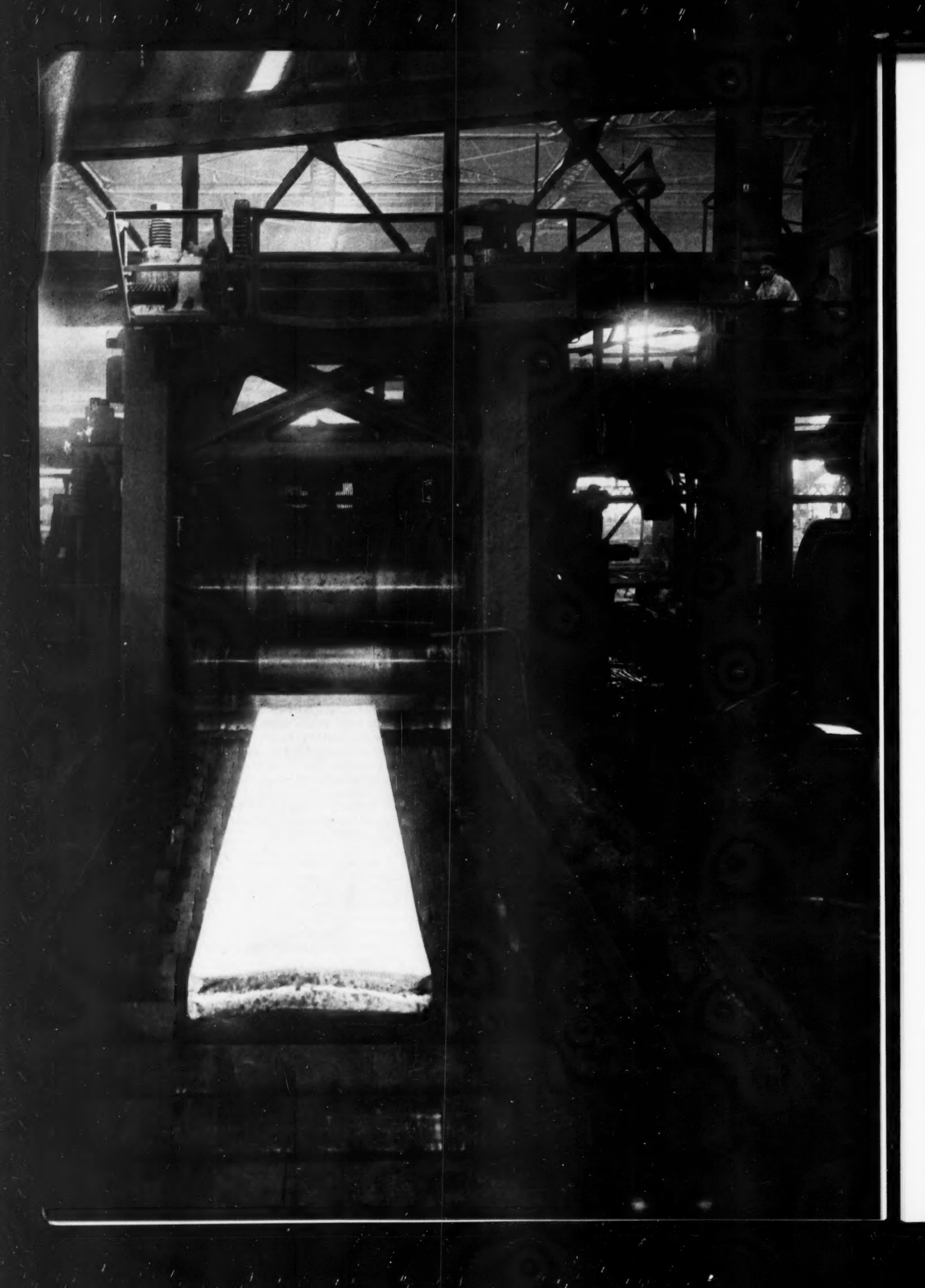
• • •

Our long range program calls for additional engineering personnel. Why not plan early for your engineering career at Allison where unlimited opportunities are offered to young graduates, especially to those with degrees in Mechanical Engineering, Electrical Engineering, Aeronautical Engineering and Industrial Engineering.

For further information about YOUR engineering career at ALLISON, discuss it with your Placement Counselor and arrange for an early interview with the ALLISON representative the next time he visits your campus. Or, write now for further information: R. G. Greenwood, Engineering College Contact, Allison Division, General Motors Corporation, Indianapolis 6, Indiana.

Allison **DIVISION GENERAL MOTORS CORPORATION • Indianapolis, Ind.**

Design, development and production—high power TURBINE ENGINES for modern aircraft . . . heavy duty TRANSMISSIONS for Ordnance and Commercial vehicles . . . DIESEL LOCOMOTIVE PARTS . . . PRECISION BEARINGS for aircraft, Diesel locomotives and special application.



Underwater Metallic Arc Welding

by ROGER C. WAUGH, MetE '54
and OTTO P. EBERLEIN, MetE '54

The May, 1953, issue of the CORNELL ENGINEER carried Messers Waugh & Eberlein's article "Penetration Factors in Metallic Arc Welding" which was first prizewinner in the 1952-53 A. F. Davis Undergraduate Welding Award Competition. The Engineer takes pleasure in presenting another paper in this field by the same successful authors.

Amazing strides have been made in the theoretical approach to welding in the past decade. The welding engineer today stands equipped with increasing knowledge of the physical and metallurgical mechanisms of such phenomena as the mode of metal transfer through the arc and the effect of various coating components in relation to arc stability and weld penetration. These represent two of the many factors integral to welding of which we now have better understanding.

Unfortunately, some promising applications of arc welding have risen to brief heights, only to be relegated to minor roles when more exacting standards were demanded. Past experience has shown that these occasional relapses were often due to insufficient theoretical knowledge of the new application. One such field is that of underwater metallic arc welding. Underwater welding proved invaluable in post-Pearl Harbor days, allowing our sunken ships to be raised in unbelievably short time.[1] It has also found considerable application in salvage and afloat-repair operations, not only to ships, but also to other subsurface structures. The problems encountered in underwater welding are of a basic theoretical nature and the process has not yet been developed to its full potential. It has been reported that hydrogen embrittlement of the weld section may reduce ductility as much as fifty percent.[1,3] The severe quenching conditions present prevent the use of this process on thru-hardening high carbon and alloy steels. This then restricts application of the process to mild steels. Two of the major problems encountered were current leakage through the extruded coating and the base metal, and the increased voltage requirements necessary to maintain the arc under the high water pressures. This latter problem also restricted the choice of electrodes, because straight polarity was found necessary to maintain the high arc voltages and prevent electrolytic corrosion of the electrode holder and circuit connections.

Interest in underwater welding has lately been renewed in another field, that of the minimization of post-welding distortion. Several manufacturers of machine tools and machine components are having varied success in attempts to reduce distortion of machined parts by welding underwater. At the present this application is in the formative stages, and is used where parts are small and only the tip of the electrode need be submerged. It is readily seen that many of the difficulties inherent in fully underwater welding are eliminated in this field. In light of this, rapid machine welding of small parts underwater may soon prove feasible.

Purpose

As the technical aspects of underwater welding become known, industry may expect to more fully utilize the process in the fields of marine repair and distortion prevention. With this in mind, the research described in this paper was undertaken as an initial effort toward a better understanding of the theoretical side of underwater welding.

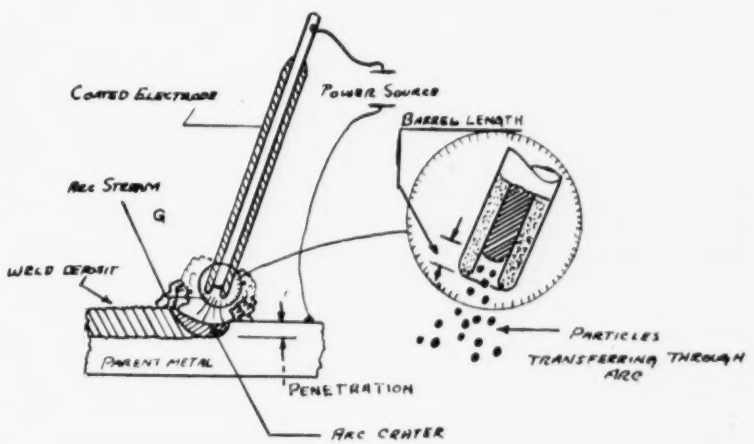


Fig. 1. Diagram of metallic arc welding, including illustration of barrel length and penetration.

The following factors were investigated by making both above- and below-water test welds using various electrodes which were coated with different waterproofing agents:

1. Operating characteristics.
2. Penetration, barrel length and bead geometry.
3. Particle size distribution.

Experimental Technique

The following ⅛-inch diameter electrodes were chosen because they exhibited varying penetrating power and are in common commercial use:

A slab of white hot steel is rolled at the mill.
—*United States Steel*

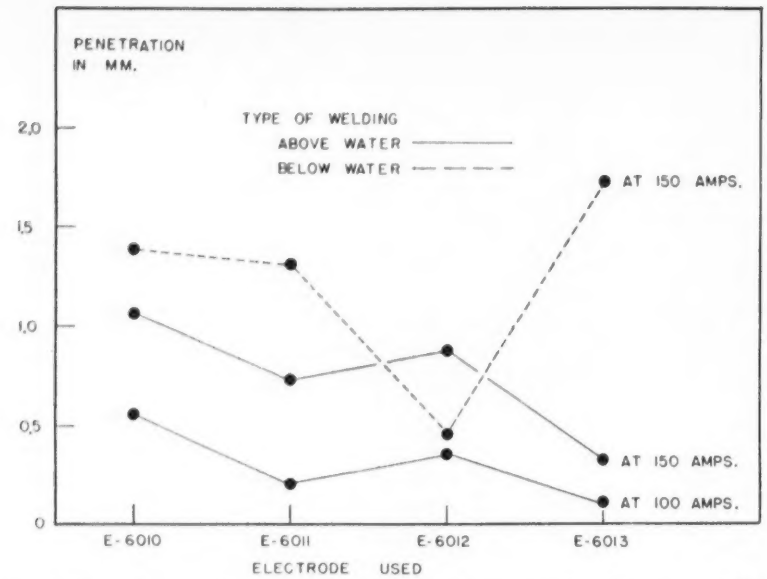


Fig. 2. **Current-penetration characteristics for above-water and below-water welding without waterproof coating.**

AWS Classification	*Polarity Used Used*
E-6010	DC-Reverse
E-6011	DC-Reverse
E-6012	DC-Straight
E-6013	DC-Straight

Each type of electrode was given waterproofing coatings of shellac, lacquer, water glass, and paraffin. Each was investigated both above and below water. Each electrode was also tested in the untreated condition.

Particles transferred through the arc in above-water welding tests were collected in the manner set forth in a previous investigation.[2] Weld passes were made along the edge of a mild steel plate, so that the particles would pass by the edge of the plate and be collected in a pan of water. The collection of particles below-water was more difficult. Two steel plates, ⅜-inch thick and five inches long were placed at angles of forty-five degrees to the horizontal in a pan of water, one plate slightly higher than the other. Their tip edges were approximately ¼ inch apart. A collecting pan was suspended in the space between the plates, and weld passes were made across the top of the higher plate with the electrode held perpendicular to the surface of the water. The depth of water over the top of the higher plate was four inches. It was noted in trial runs that particles rolling off the higher plate had sufficient velocity to carry them over the top of the lower plate, so that they were not collected. Hence, only particles passing directly through the arc and past the edge of the plate were collected in the submerged pan.

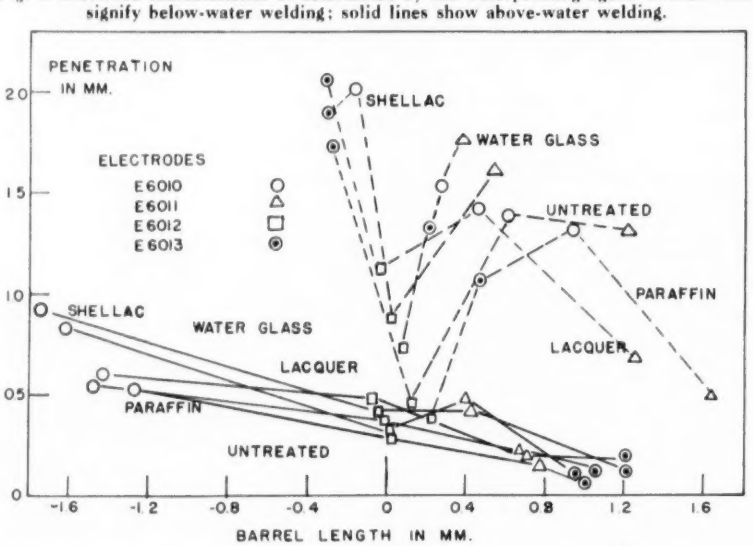
All particles collected for each test were separately dried, screened, weighed, and plots of cumulative percent retained versus mesh size were made for each of the four electrodes at all of the five coating conditions.

Test beads were made for each electrode and waterproofing material combination below four inches of water. Each barrel length which, for the case of a positive barrel length, is the distance between the tip of the extruded coating and the tip of the filler wire as shown in Figure 1, was measured and recorded. Average values of barrel length were obtained from three runs at each condition. Each weld was sectioned, polished, and etched so that the depth of penetration into the plate could be determined. Again, the average of three runs was determined. A Brinell microscope was used to measure the values of barrel length and penetration.

In all penetration tests weld beads were made on ¼-inch thick SAE 1020 steel plate using a 3/16-inch arc length and an electrode travel rate of 15 inches per minute. A fifty-percent increase in welding current was used to offset the anticipated underwater current leakage. Hence, welds were made at 100 amperes above water and at 150 amperes below water. In order to evaluate this estimate of current leakage, test welds were also made above water at 150 amperes using electrodes without waterproofing coatings. Depth of penetration and barrel length were determined at these conditions, holding the previously mentioned conditions constant.

Unsuccessful attempts were made to weld underwater using alternating current. Regardless of the current magnitude used, it was impossible to maintain the arc due to the cyclic changes in current.

Fig. 3. **Electrode characteristics as determined by the waterproofing agent. Broken lines signify below-water welding; solid lines show above-water welding.**



Current-Penetration Characteristics

Figure 2 indicates the relation which exists between penetration and welding current for both above- and below-water welding with untreated electrodes. The effect of increasing the above-water welding current from 100 to 150 amperes caused, as anticipated, an increased depth of penetration for all of the electrodes. The increases for the E-6010, E-6011, and the E-6012 were approximately equal to 2½ mm. The effect on the E-6013 was not as pronounced as on the others, increasing penetration only slightly more than one millimeter.

For all four electrodes the penetration obtained by welding at 150 amperes underwater was greater than the corresponding above-water penetration at 100 amperes. The minimum increase, 30%, was with the E-6012 electrode. The other three showed increases of greater than 100%. This fact may be explained on the basis that the coating of the E-6012 rod offers less resistance to current flow when immersed, and thus has a correspondingly greater current leakage during underwater operation. From these two curves it is apparent that the estimate of underwater current leakage of one-third of the total current is too high for all but the E-6012 electrode. In light of these tests, it is felt that a current increase in the order of ten to twenty percent would have been sufficient to compensate for leakage losses. The fact that the underwater current leakage was over-estimated should be borne in mind during the discussion of the actual test results which appears in a later section.

A comparison of the curve for underwater welding at 150 amperes with the above-water curve at 150 amperes shows that the untreated E-6010, E-6011 and E-6013 electrodes give deeper penetration below than above water. Only the E-6012 gives deeper above-water penttration. The deeper underwater penetration of the three electrodes is indeed perplexing when one thinks solely in terms of equal electrical power input and postulated loss of current due to leakage during immersion. On such a basis alone this phenomena is unexplainable. Its understanding lies in the fact that the characteristic above-water weld bead contour below the surface of the parent metal is not the same as the below-water contour. The above-water weld contour is a concave upward, button-like type of deposit. The under-water weld contour, on the other hand, is trough-shaped, a cross-section of the weld being similar in appearance to the keel and side strakes of a ship. Thus in the case of the underwater weld the actual amount of weld metal deposited beneath the surface of the parent metal is less than that present in the corresponding above-water weld cross-section. The penetration is deeper, however, due it its characteristic bead shape. In terms of weld geometry, therefore, the apparent power paradox is readily understandable. The underwater E-6012 weld is shallower than the corresponding above-water weld due to the magnitude of its current leakage during underwater operation.

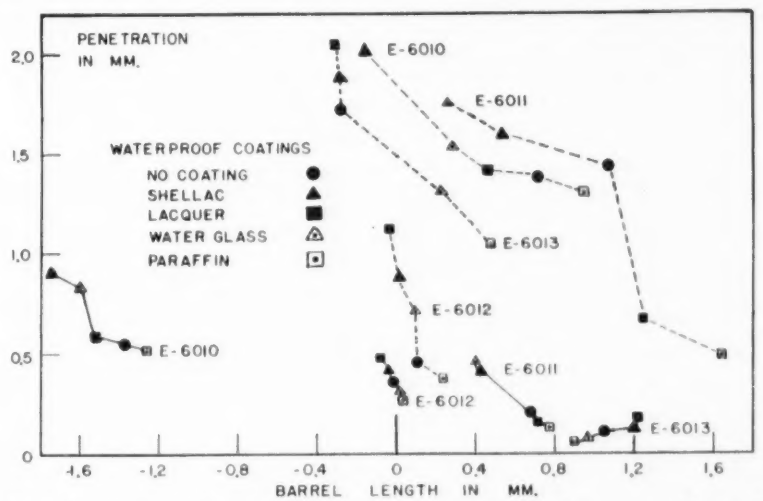


Fig. 4. Specific electrode characteristics. Broken lines signify below-water welding and solid lines indicate above-water welding.

Electrode Characteristics as Determined by the Waterproofing Agents

Figure 3 shows the effect of various waterproofing agents upon the operating characteristics of the four electrodes studied. Variation of barrel length with depth of weld penetration is plotted for each electrode and waterproofing agent combination for welds made above and below-water. On the basis of this graph a number of interesting correlations can be made.

It was noted that welding underwater gave deeper penetration than welding above-water for each test combination investigated. The import of this statement, however, should be tempered in light of the over-estimated current leakage, as previously discussed.

The E-6011 electrode was found to have the longest barrel length in underwater welding for all waterproofing agents as well as the untreated condition. Oddly enough, this behavior is not characteristic of this electrode in above-water welding. To the contrary, with three combinations it had the shortest barrel length and with the other two it was the second shortest.

For every coating condition except waterproofing the rod with lacquer, the E-6012 electrode had the shallowest underwater penetration. Within the group of electrodes coated with lacquer, the E-6012 electrode was second in shallowness of penetration to the E-6011. A possible explanation for this phenomena is, as was postulated earlier, that the E-6012 is the least resistant to current leakage during underwater operation. From Figure 3 it is noted that the underwater depth of penetration for the untreated E-6012 electrode is 0.46 mm. Comparing this value with the others for the treated condition it is seen that the shellac, water glass, and lacquer considerably increase the observed penetration. This may be attributed to a reduction in the magnitude of the current leakage.

Surprisingly, the paraffin coating has the opposite effect, and causes a slight reduction in penetration. This effect of paraffin is not limited solely to the E-6012 electrode, but is also found in the other three rods. It would thus appear that the paraffin increases the magnitude of the current leakage. Similarly, the depth of penetration of the E-6011 is decreased by the lacquer coating and the E-6013 by the water glass.

A comparison of the depth of underwater penetration of the four untreated electrodes is revealing. The depths of penetration of E-6010, E-6011 and E-6013 fall within the range of 1.3 - 1.7 mm., whereas the E-6012 rod only penetrates to a depth of 0.46 mm. On the basis of surface coatings, this is probably due to the fact that the E-6012 rod is characterized by having the least resistance to current leakage through the coating while operating immersed. The E-6012 electrode is the only one to have a negative barrel length while operating underwater in the untreated condition.

Shellac as a waterproofing agent generally causes the formation of shorter barrel lengths than do the other waterproofing agents. Both the E-6010 and E-6013 have negative barrels and the E-6012 has a positive barrel length of only 0.02 millimeters.

The plot of penetration versus barrel length for underwater welding using electrodes coated with water glass gives an interesting correlation. Figure 3 shows a linear relation which has a positive slope. From this it is seen that the depth of penetration increases with increasing barrel length. This is, in itself, a surprising observation, since it is a sharp contradiction to the established rule for above-water welding with untreated electrodes that the depth of penetration and barrel length vary inversely.[2] It is also noted that the similar underwater curves for the other coating treatments investigated violate this generalization. It is apparent, therefore, that the inverse relationship does not hold for plots of the underwater characteristics of the electrodes which have received the same waterproofing coating.

The inverse relation discussed above will be seen in Figure 4 to hold very well for the below-water plots of the same electrode with different waterproofing coatings. The sole exception to this is the case of the water glass coated E-6011 electrode. It should be mentioned here that the inverse relationship is borne out by the fact that the graphical electrode order is maintained independent of the waterproofing agent used. In order of having the longest barrel and least penetrating power the E-6013 ranks first. The ranking of the others from this is E-6011, E-6012 and E-6010. The coating condition generally had little effect on the characteristic depth of penetration and barrel length of the electrode in above-water welding.

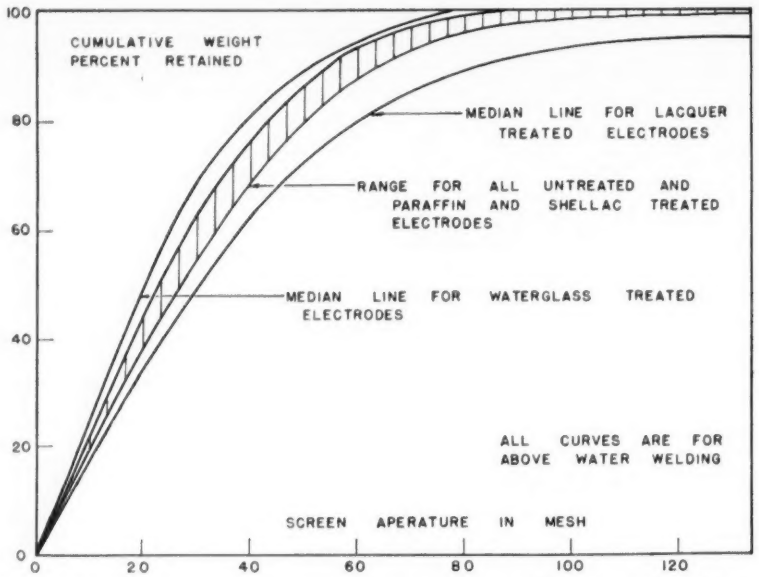


Fig. 5. Effect of electrode and waterproofing agent upon particle size distribution in underwater welding.

Electrode Behavior

Figure 4 shows the above and below-water variation in depth of penetration with barrel length as affected by the waterproofing agent for each electrode. It is seen that the below-water penetration of each electrode is greater than the above-water penetration for all of the waterproofing agents. This is as expected considering that the magnitude of the current leakage was over-estimated. With both above-water and below-water welding the paraffin coating caused the shallowest penetration for all electrodes. It also gave the longest barrel lengths for all cases except above-water welding with the E-6013 rod. Barrel length was found to vary inversely with the depth of penetration for all cases except above-water welding with the E-6013 rod. Generally, the above-water welding was characterized by a narrower spread of barrel length and depth of penetration values for any given electrode than was obtained in below-water welding. The E-6010 electrode may be singled out as the only one which gave negative barrel length in above-water welding with all of the coating conditions investigated. The E-6011 rod was the only one which gave positive barrel lengths with all coating conditions for both above-water and below-water welding. For all coating treatments the E-6012 electrode gave exceptionally short positive and negative barrel lengths for both above and below-water welding.

Particle Size Distribution

The effect of electrode and various waterproofing agents upon the particle size distribution curves for both below-water and above-water welding is shown in Figures 5 and 6. In both of these figures a particle size distribution range and two median curves are shown. For either figure the range of each of the two median curves is approximately the same as the range indicated on the figure. The median curve type of particle size distribution representation was selected in

(*Continued on page* 46)

Synthetic Gems

by LAVONNE OLSON, ChemE '57

Minerals of economic importance can be divided into three groups. The first group contains minerals which provide a source of energy, such as coal and radioactive elements. In the second group, the minerals are valuable because they contain useful elements, such as copper ores, galena, and pyrite. The minerals of the third group are useful as they occur in nature for their particular physical properties.

From earliest times the minerals of this third group have held a particular fascination for mankind. In this group are the gemstones, the pigments, the legendary Philosopher's Stone. Historically, they have been used as a medium of exchange; they have played an important role in the longing of man for protection and for power. Lazurite in the form of beads was used by the ancient Greeks and has been found in the ruins of Troy. It was a favorite of the ancient Babylonians and Assyrians and has been found in the treasure house of the Pharoah Rameses. In the middle ages this lazurite was brought into Europe from Tibet and Afghanistan. Marco Polo described the tedious process of extracting from it the dark blue pigment called ultramarine which was very much in demand and sold for as high as $30 a pound.

From earliest times, also, there have been efforts to reproduce these minerals synthetically. For centuries, alchemists tried to change base metals into gold with the mysterious catalyst, the Philosopher's Stone. It is only during comparatively recent years that true synthetic minerals have been produced.

By definition, synthetic minerals are man-made materials which possess the same chemical, physical, and optical properties as their natural counterparts. Any manufactured mineral that does not have the identical properties should be classified as imitation, artificial, or simulated.

The Synthetic Gem Industry

During the 18th century, chemistry and mineralogy developed into exact sciences. Mineralogy then started to grow into an experimental science, and the middle of the last century, in France, marked the beginning of the synthetic era of mineralogy.

In 1904, the Verneuil flame fusion process was developed which made possible the synthesis of rubies. With minor modifications, this same process has since produced millions of carats of sapphire, ruby, and spinel ($MgO.3\frac{1}{2}Al_2O_3$). More recently star sapphires, star rubies, titania, and single-crystal tungstate phosphors have been manufactured in the United States by a modified Verneuil process.

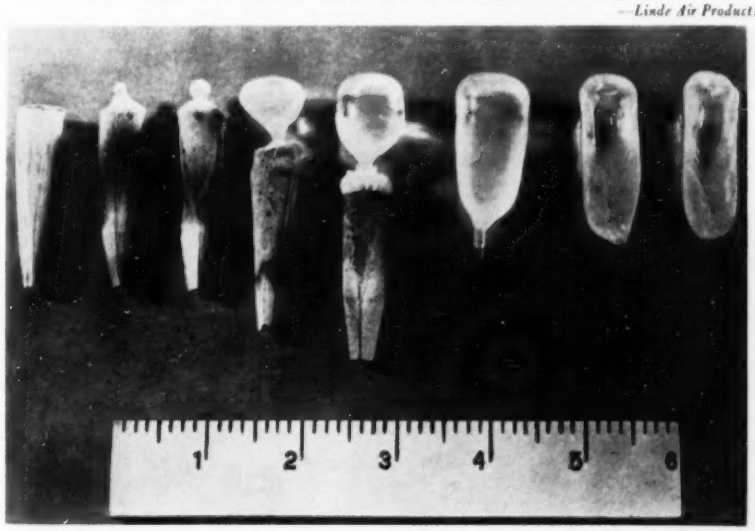
Until the Second World War, the synthetic gem industry was concentrated in Europe, with one-half of the world's production being in Switzerland. The heavy demand of the Swiss watch and instrument industry for sapphire and ruby bearings gave Switzerland the initiative for developing this industry.

The United States imported synthetic minerals from Europe until World War II when demand for jewel bearings for instruments far outran the supply. Also needed was a supply of large and flawless single crystals for optical purposes and for certain electronic devices. These are not available naturally in required quantity, so synthesis was essential. Actual details of European plant equipment and process control were closely guarded trade secrets. Despite the handicap of having to start at the beginning, American industry, led by Linde Air Products Company, took only 18 months to develop a "boule" growth process. Since 1942, American industry has maintained synthetic crystal manufacturing facilities adequate to satisfy its industrial and jewelry demand.

Methods of Mineral Synthesis

There are various methods of mineral synthesis used today. Early-

Here samples of boules are shown in various stages of crystal growth.
—Linde Air Products



known methods are precipitation and crystal-growth from solutions.

Many mineral pigments can be formed by precipitation from aqueous solution at ordinary or slightly elevated temperatures. The color of these compounds depends on particle size and crystal structure, so manufacturing controls are essential for uniformity. Some of the pigments produced by this method are barite ($BaSO_4$), galena (PbS), and crocoite ($PbCrO_4$) according to the following equations:

$$BaCl_2 + Na_2SO_4 = 2NaCl + BaSO_4$$

$$Pb(NO_3)_2 + (NH_4)_2S = 2NH_4NO_3 + PbS$$

$$Pb(NO_3)_2 + K_2CrO_4 = 2KNO_3 + PbCrO_4$$

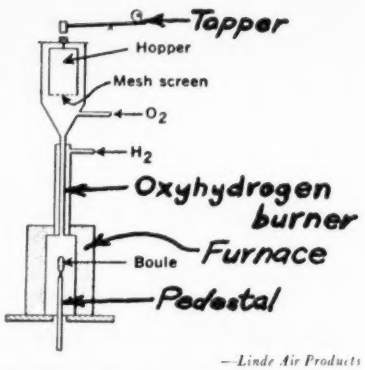
The mineral greenockite (CdS) is of no economic importance, but the synthetic product is a valuable yellow pigment produced by the reaction of cadmium salts with H_2S in aqueous solution. For some grades of the pigment, a more indirect method is used. By synthesis, there is quantity and color control which is unattainable from the natural minerals.

Crystal growth from solutions involves allowing an aqueous solution of the desired mineral of reagent quality to stand until the water evaporates and the material crystallizes. An "impurity" is sometimes added to give the crystal the desired properties. For example, if large, clear, single crystals of NaCl free of inclusions are desired, the process is to add a trace of stannous chloride or lead chloride to a reagent quality aqueous solution of sodium chloride.

In nature, most perfect crystals must have formed where the proper impurities were available. The finest specimens of crystals contain traces of alumina and alkali. Ultraviolet absorption reveals the presence of impurities in the diamond of gemstone quality that is not present in other forms of carbon.

Most piezoelectric materials are grown from aqueous solution. These materials have no center of symmetry. When a shear stress is applied to the crystal, the shift of the electric charges of the ions produces an electric effect which can be used to change acoustical waves into electrical impulses. The minerals tourmaline, rochelle salt, ammonium dihydrogen phosphate, and lithium sulfate monohydrate are all valuable for oscillator control.

Another method of synthesis is the formation of crystals from the melt. A crucible with a conical bottom is lowered through a vertical furnace. A high temperature gradient is established in the melt which causes the crystallization to begin at the bottom and to grow upwards through the melt. Single crystals, particularly NaCl, KBr, KI, LiF, and CaF_2, are used for ultraviolet and infrared optics. Ingots of AgCl single crystals can be rolled between highly polished rolls, and the sheets used for windows and absorption cells for infrared light.



—*Linde Air Products*

Apparatus used in the Verneuil flame fusion process.

Another method of synthesis consists of allowing a mixture of oxides to react in the solid state. The resulting crystals are very small, often submicroscopic. Some of the oldest pigments, such as Egyptian blue (calcium cupric silicate) and ultramarine (lazurite), are now produced commercially by solid state reactions. Since properties like color and fluorescence depend on crystal size, the heat treatment must be carefully controlled. Frequently catalysts and fluxing agents are added to speed up recrystallization and to control particle size. This process also yields minerals with desirable magnetic properties, such as a solid solution of FeO, NiO, and CoO.

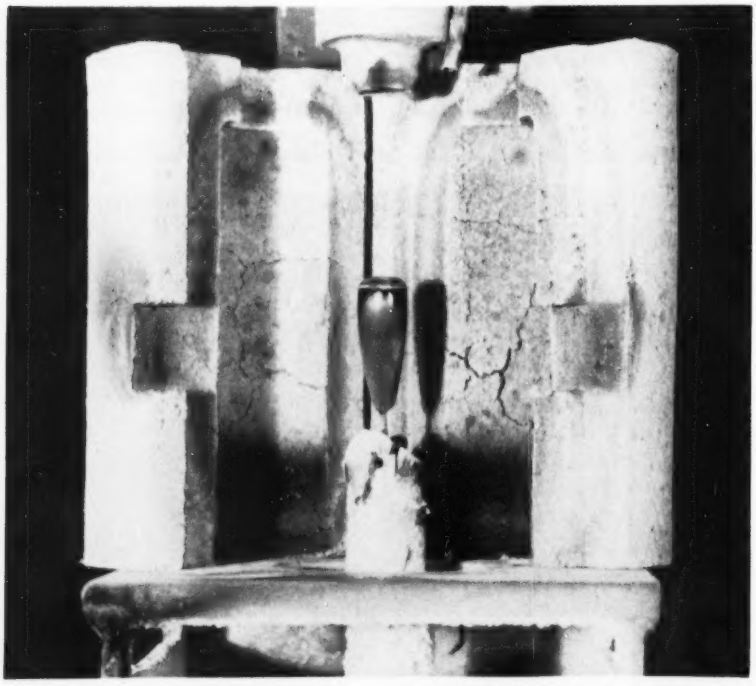
Volcanic activity produces minerals that can be synthesized from the vapor phase as a result of either chemical reaction or sublimation. Reaction between CO and SO_2 at 1000-1200°C. yields elementary sulfur. The sublimation method is used in the synthesis of greenockite (CdS). Single crystals of CdS are produced by reacting the vapor of metallic cadmium with hydrogen sulfide.

$$Cd + H_2S = CdS + H_2$$

The crystals are used as X-ray detectors because they can convert

Boule on the pedestal can be seen in the boule-growth furnace.

—*Linde Air Products*



X-ray quanta into slow electons.

Verneuil Process of Synthesis

Probably the most important method of mineral synthesis is the flame fusion or Verneuil process mentioned before in connection with the production of jewel bearings and synthetic gems. This method also yields minerals with desirable thermal properties, such as mullite, $3Al_2O_3 \cdot 2SiO_2$, which is highly refractory.

The single crystals produced by the Verneuil process are called "boules." A corundum boule is a single crystal of alpha-alumina (Al_2O_3) ½-1 inch in diameter and up to 6 inches in length. Spinal crystals are of the same size, while titania crystals are somewhat smaller.

The powder used as starting material must be spectrographically pure. For corundum, alum ($NH_4Al(SO_4)_2 \cdot 12H_2O$) is the feed material; for spinel, a mixture of alum and ammonium magnesium sulfate is used. The pure sulfates are obtained by precipitation from aqueous solution.

The crystals of the synthetic corundum (rubies and sapphires) and spinel family are colored by the addition of small quantities of metal oxides such as chromic oxide, titanium dioxide, and iron oxide to the material used in their manufacture. For example, the addition of titanium and iron oxides to the uncalcined alum will yield a blue sapphire, cobalt oxide will give a green stone, and nickel and magesium oxide impurities will give the golden or "topaz" sapphire.

The alum and colorant metal salt are then calcined together to give uniform distribution of the colorant. Shallow fused quartz dishes, each charged with two pounds of alum, are placed in hot gas-fired muffle furnaces and calcined at 1000-1100°C.

After cooling, the material in the form of a cake is screened to give the fine powder used in the boule growth apparatus.

Pure TiO_2 powder for the production of titania (also called rutile) is prepared by calcining hydrolyzed titanium tetrachloride or titanyl sulfate in an oxidizing atmosphere at a temperature of about 500°C. Extremely pure powder is required to give the desired very pale yellow-colored crystals. During the growth process, the titania boule is black and opaque due to a composition of slightly less oxygen than corresponds to the formula TiO_2. A separate heat treatment in an oxidizing atmosphere satisfies the oxygen requirement and gives a clear material.

—by Maria Martel, Better Living Magazine

The seven rings shown above cost a total of $875. If the stones were genuine, the same rings would cost $19,995.

Except for mechanical improvements the present commercial production of synthetics utilizes the same basic oxy-ghdrogen flame process developed by Vernevil. The apparatus consists of a hopper, oxy-hydrogen burner, ceramic furnace, and ceramic pedestal on which the boule grows.

The purified, calcined powder is placed in the hopper, which is equipped with a fine-mesh screen bottom. During the growth cycle the hopper is tapped, causing the powder to feed intermittently into the oxygen stream which flows down through the center tube of the burner. Surrounding this inner orifice of oxygen and powder is a larger outer orifice through which is fed hydrogen at reduced pressure. The arrangement thus consists of a stream of oxygen reacting in an atmosphere of hydrogen. The ratio of hydrogen to oxygen in corundum synthesis is usually about 3:1, providing there is sufficient temperature to reach the 2050°C. required for the fusion of alumina.

The powder falling through the flame builds up as a sintered mass on the ceramic pedestal, having a rod-like shape at first. By careful control of the flame, and by lowering the boule with the vertical screw adjustment on the pedestal, the crystal grows until it is ¼ inch long and has the diameter of a match stick. Then conditions are changed so that a ball forms on the top of the rod. This broadens to resemble a small mushroom. When the diameter has reached standard boule size, the conditions are again changed and maintained until the desired length is attained. The growth process is then stopped and

(Continued on page 49)

ENGINEERS IN CIVIL DEFENSE - II

by HOWARD C. YOUNG, M.E. '19

To supplement the resources of the states and their target areas, FCDA has arranged for the storage of certain items of engineering equipment near those areas. This equipment is especially adapted for use in national emergencies. It includes 8-inch quick-coupling lightweight steel pipe, couplings, fittings and gate valves, centrifugal pumps, portable water purifiers, mobile chlorinators, portable generator sets and flexible vinyl film specially designed for emergency window closure. As of January 1954, stocks of these items were available at thirty-seven different strategic locations throughout the country.

—George Lohr

Fig. 4. Employees of the FCDA supervise the installation of an 8" quick-coupling lightweight pipe unit.

Eight-inch Lightweight Pipe

The quick-coupling features of this lightweight steel pipe provide an easy, rapid method of extending pipe lines over all kinds of terrain to bring water from a river, lake, reservoir or other source to a point where it can be used for fire-fighting or other essential community need. (See figure 3.) In a trial exercise at New York City 1000 feet of this pipe were laid on the downtown streets, connected to a source of water supply, and water delivered to fire department pumpers by untrained workers in twenty minutes.

The couplings are installed on the pipe joints to make waterproof connections. The pipe assembly is accomplished by two pipe crews of six men each, working simultaneously on alternate coupling joints. One crew performs the first coupling operation; the other crew then installs the coupling at the second joint. Both crews proceed along the line of pipe, coupling alternate joints and by-passing each other as they go.

Centrifugal Pumps

The FCDA centrifugal pump has a capacity of 1500 gallons per minute at a discharge pressure of 100 psi at 2100 rpm. It weighs about 6,000 pounds and is mounted on wheels. Normally it will be carried on a low-bed trailer or other suitable carrier to the emergency source of supply (river, lake or reservoir), then rolled into position by a 6-man pump crew. These pumps can be used as boosters along the line at some distance from the primary unit. Two of them may be connected directly in series to obtain a discharge pressure of approximately 200 pounds per square inch, if needed. About 5 of these pumps are allotted with each 10 miles of the 8-inch lightweight pipe stored near target cities.

Portable Water Purifier

The FCDA 100-gallon-per-minute portable water purifier (See Figure 4.) consists of the following six components, all mounted on a steel skid: (1) pumping unit, (2) diatomite filter, (3) Precoat circulating tanks, (4) filter-aid tank and feeder, with supply of filter aid, (5) hypochlorite tank and feeder, with supply of hypochlorite, and (6) rate-of-flow controller and indicator.

Filtering of raw water from a nearby surface source such as lakes, river, spring, or well is accomplished by forcing the water through a cake of diatomaceous earth by applying diatomite to the outside of the vertical filtering elements in the filter. Backwashing is accomplished by reversing the flow in the supporting element and discharging the clogged diatomaceous earth to waste. Two 3000 gallon rubber-coated nylon collapsible storage tanks are provided with each water purifier unit to store the filtered water at the site of the unit for use as needed. One man can operate these units, but a crew of 3 or 4 skilled operators is needed for continuous operation.

An auxiliary pump having the same characteristics as the pump on the purifier is also supplied. It could be used to replace that pump if necessary, or to lift filtered water from the collapsible storage tanks into tank trucks for distribution to other points.

Mobile Chlorinators

The FCDA mobile chlorinator (See Figure 5), another stockpiled

item, is trailer-mounted and designed for towing by truck or automobile. Its major function is to decontaminate broken water mains in a major emergency. The chlorinators consist of two component parts: the chlorine control apparatus and the turbine-type pumping unit. The pump is self-priming, and is driven by a gasoline engine directly connected through a flexible coupling. It applies chlorine to water for the emergency chlorination of water supplies, for the disinfection of mains, and for the decontamination of reservoirs, basements, and other spaces within buildings. The pump discharges water through an injector where a vacuum is created. The chlorine is mixed with the water at that point. The chlorine solution is then discharged to the point of application. One operator can operate the chlorinator. But to assure 24-hour operation, a crew of 3 or 4 operators will be needed for each mobile chlorinator.

—George Lohr

Fig. 5. This 30 kilowatt portable generator is one of the FCDA stockpiled items.

Portable Generator Sets

FCDA has stockpiled portable electric generator sets in four sizes: 5-KW, 15-KW, 30-KW, and 40-KW to furnish temporary electric power for essential buildings such as hospitals, first-aid and welfare centers, and similar places in civil defense emergencies. (See Figure 6) Each generator set consists of (1) a gasoline-engine drive direct-connected to (2) an alternating current generator with direct-connected exciter, and (3) a built-in control panel for manual operation. The 5-KW set supplies either 120 or 240-volt, 60-cycle single-phase alternating current; the 15-KW, 30-KW, and 40-KW sets generate either 120 or 208 volt, 60-cycle 3-phase alternating current. These generator sets are skid-mounted, and they can be pulled along the ground for short distances at speeds not exceeding 3 miles per hour. After installation, one operator per 8-hour shift can keep the generator running. To maintain 24-hour operation, a crew of 3 or 4 operators is needed.

Fig. 6. Another important item is this portable water purification unit, capacity—100 gallons per minute.

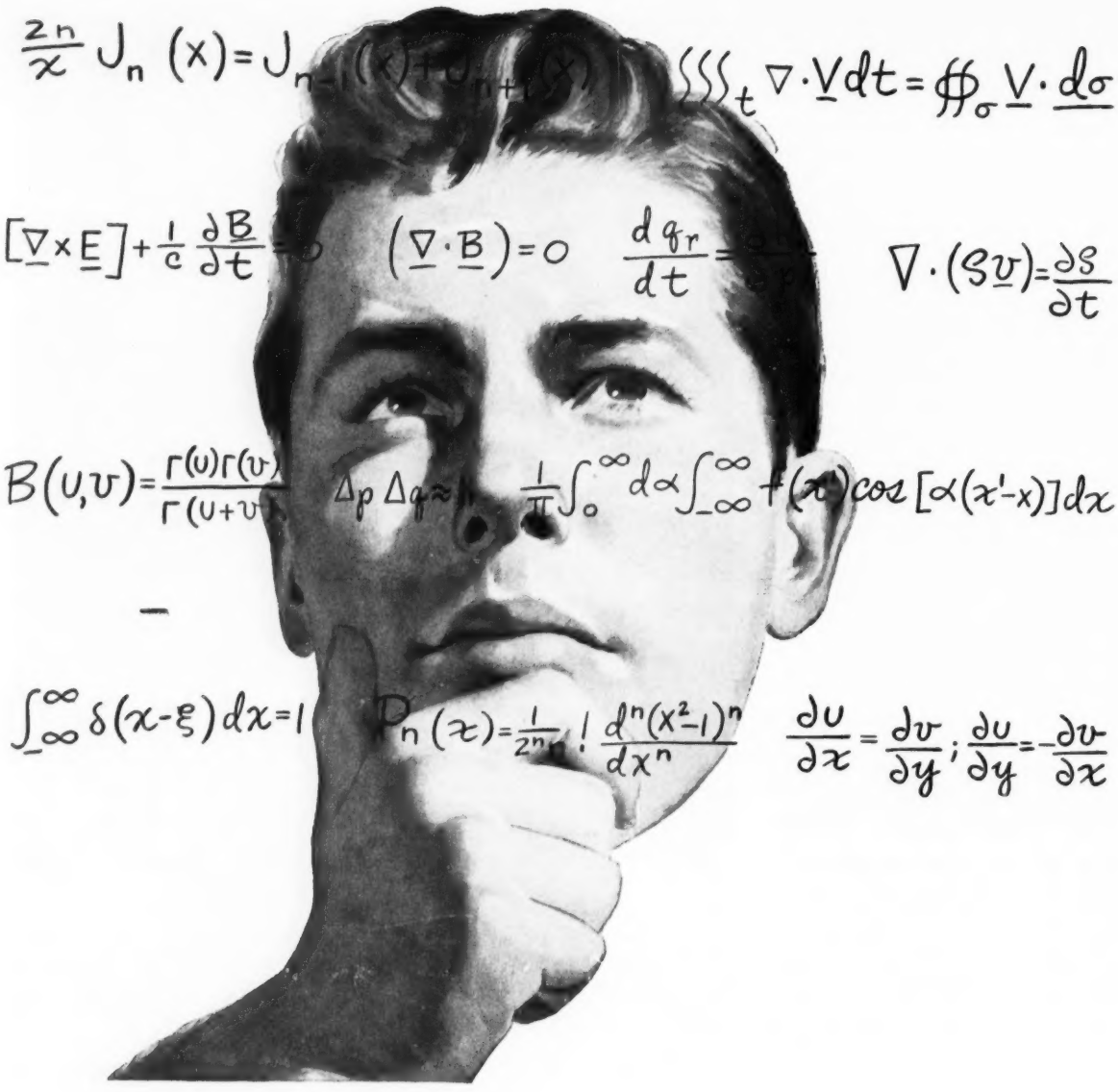
—George Lohr

For use as emergency closures in window and door openings of hospitals, sanitariums and other essential buildings immediately following attack, FCDA has stockpiled a quantity of flexible vinyl film. This material is .004-inch thick, has a translucent finish, and is designed to protect casualties from inclement weather for 1 to 6 months until the carpenters and glaziers needed to install new frames and glass become available. It is stored in 350-yard rolls 54 inches wide, and packed in 12 inch x 12 inch x 60 inch cardboard cartons. When kept in a cool place it should have a shelf life of at least 5 years. A suitable liquid adhesive for fastening the film to the building openings is stored with it. A crew of 6 men or women is needed for installing the film; for 24-hour operation crews of 8 operators will be trained for this work.

Summary

The above discussion shows clearly the need for intensive planning by engineers to be able to cope with the devastation and confusion that follows enemy air attacks. A variety of engineering skills are needed (1) to select the

(*Continued on page* 49)


$\frac{2n}{x} J_n(x) = J_{n-1}(x) + J_{n+1}(x)$
$\iiint_t \nabla \cdot \underline{V} dt = \oiint_\sigma \underline{V} \cdot d\underline{\sigma}$
$[\nabla \times \underline{E}] + \frac{1}{c}\frac{\partial B}{\partial t} = 0$
$(\nabla \cdot \underline{B}) = 0$
$\frac{dq_r}{dt} =$
$\nabla \cdot (S\underline{v}) = \frac{\partial S}{\partial t}$
$B(u,v) = \frac{\Gamma(u)\Gamma(v)}{\Gamma(u+v)}$
$\Delta p \, \Delta q \approx$
$\frac{1}{\pi}\int_0^\infty d\alpha \int_{-\infty}^{\infty} f(x)\cos[\alpha(x'-x)]dx$
$\int_{-\infty}^{\infty} \delta(x-\xi)\,dx = 1$
$P_n(x) = \frac{1}{2^n n!}\frac{d^n(x^2-1)^n}{dx^n}$
$\frac{\partial u}{\partial x} = \frac{\partial v}{\partial y}; \frac{\partial u}{\partial y} = -\frac{\partial v}{\partial x}$

To a young engineer

. . . with his eye on the future

All your life you've been heading for this . . .

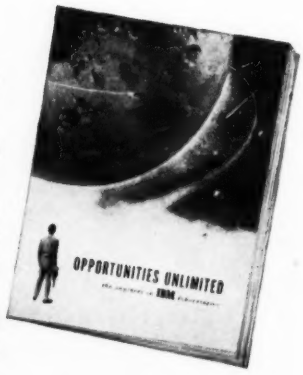
A place where ideas flourish, grow into realities.

A place where you're creating; contributing to human progress; using to the full your engineering education.

A place where what a man knows and what he can do are the things that determine his future.

Here at IBM, whether you're an ME, EE, or Engineering Physicist, whether your major interest is research, product design, or product development, there's something big for you to do, something that gives you not merely "job satisfaction," but job enthusiasm!

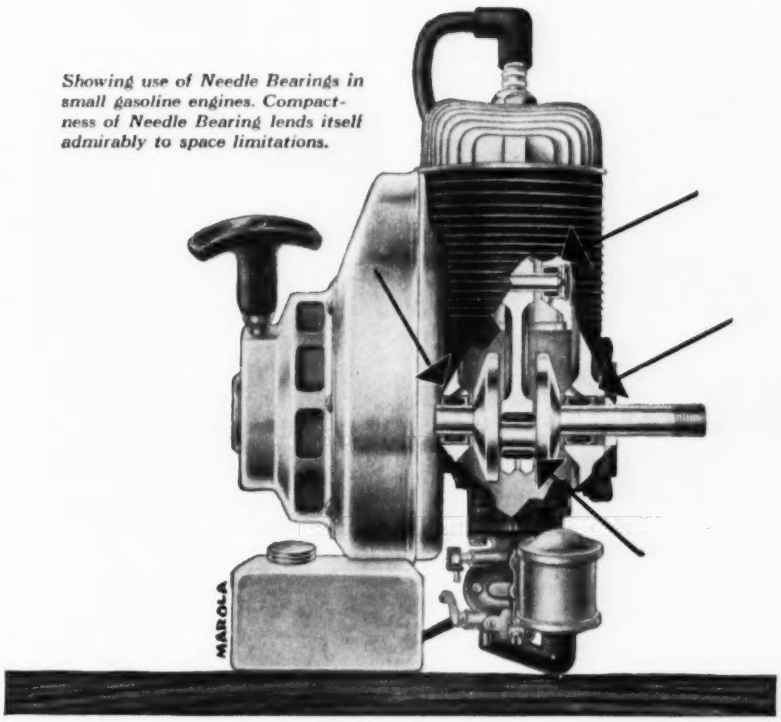
Your placement officer has copies of a new 32-page brochure picturing work at IBM Engineering Laboratories. It's titled "Opportunities Unlimited." Ask him for a copy today. Or write Mr. W. M. Hoyt, Engineering Recruitment Office, International Business Machines, 590 Madison Avenue, New York 22, N. Y.



IBM
TRADE MARK

Leading manufacturer of electronic digital computers, electronic and electrical business machines, time systems and electric typewriters.

Torrington Needle Bearings save weight and space in many designs



Showing use of Needle Bearings in small gasoline engines. Compactness of Needle Bearing lends itself admirably to space limitations.

Because of its unique construction—a full complement of small diameter rollers retained in a one-piece thin drawn outer shell—the Torrington Needle Bearing has a small cross section. This makes it extremely useful in bearing applications where space and weight are at a premium.

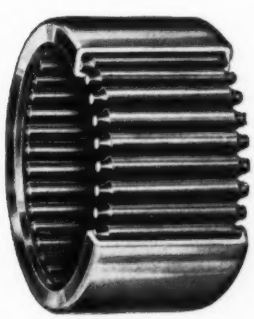
For a given load capacity, the Needle Bearing is the smallest and most compact anti-friction bearing available, giving the designer many opportunities to reduce the size and weight of surrounding members without lowering performance.

Smaller, lighter products

In an application like the small gasoline engine illustrated, Needle Bearings help keep overall size and weight to a minimum. Housings can be made smaller and lighter without sacrificing shaft stiffness and strength. What's more, the Needle Bearing's low coefficient of starting and running friction plus its ability to retain lubricants results in increased power output.

Simpler designs

Since a press fit in a simple straight housing bore is all that is required to locate a Needle Bearing, the use of complex retaining shoulders or rings is unnecessary. And, since the Needle Bearing usually runs directly on a hardened shaft—without an inner race—additional savings in space and weight are gained.



THE TORRINGTON COMPANY

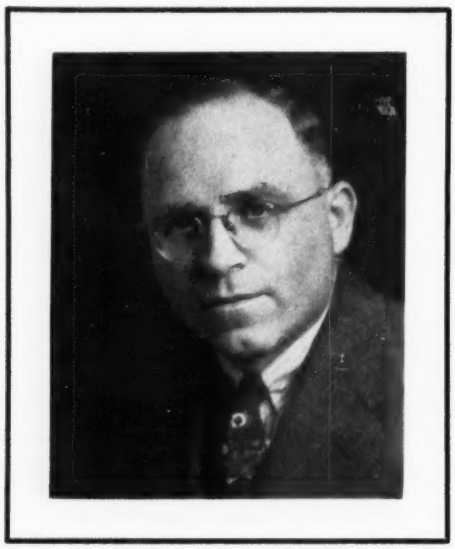
Torrington, Conn. • South Bend 21, Ind.

District Offices and Distributors in Principal Cities of United States and Canada

TORRINGTON NEEDLE BEARINGS

NEEDLE • SPHERICAL ROLLER • TAPERED ROLLER • CYLINDRICAL ROLLER • BALL • NEEDLE ROLLERS

IN MEMORIAM



PROF. WALTER R. JONES

With the unexpected death, on March 8, of Professor Walter Roy Jones, the Cornell community has lost a renowned and beloved citizen. His passing has brought great sorrow to the many many personal and professional friends he leaves behind and to people throughout this country who knew him. He will always be remembered by students and by associates as a man with a deep fund of knowledge, a love for activity, and an ever-willingness to advise, assist, and work with people.

When Walter R. Jones graduated from the School of Electrical Engineering at Cornell in 1925, he joined the Federal Radio Corporation of Buffalo as a test engineer and there later became chief engineer in charge of research and development In 1929 he moved to Emporium, Pennsylvania, where he worked first as a sales engineer and then as chief engineer for Sylvania Electrical Products, Inc.

In 1948 he returned to Cornell as associate professor and in 1951 was made a full professor of electrical engineering. His wide experience, his remarkable analytical ability, and his most pleasing personality led him into a diversity of pursuits to which he applied his endless energy. He was a senior member of the Institute of Radio Engineers, a fellow of the Radio Club of America, president of the Ithaca chapter of the American Institute of Electrical Engineers, a member of the Society of Motion Picture Engineers, Sigma Xi, and Eta Kappa Nu.

As coordinator for research at Cornell in electrical engineering from 1948 to 1953, Professor Jones played a major role in the School's development and research program, and he was instrumental and chiefly responsible for the establishment of the vacuum tube laboratory here.

Considered one of the world's topmost experts on the design and construction of vacuum tubes, he had since 1951 directed studies in his laboratory for the Army Signal Corps which are expected to lead to the production of a more reliable, higher grade, vacuum tubes. For work during World War II he was cited by the Office of Scientific Research and Development.

Professor Jones' interest and attention were claimed by many things outside his professional field. He was a holder of the Silver Beaver for Boy Scout work, was quite active in the Methodist Church of Ithaca; and loved to fish.

It is virtually impossible to present in a printed piece more than a very small token to the value of such a man. Given is only a suggestion of his interest in friends and students and their problems, as well as selfless donation of his wisdom. Professor Jones' untimely death at 51 is a severe blow to the School of Electrical Engineering, where he was a tremendous influence and inspiration in the progress of the school.

His passing is felt as an irreplacable loss.

"I chose Worthington for opportunities in international trade"

• "Worthington was my choice," Mr. Berger says, "because of the excellent training and the unusual experiences that are possible with a manufacturer having a worldwide reputation, and worldwide distribution. Then, when a company has seventeen divisions, including air conditioning, refrigeration, turbines, Diesel engines, compressors and pumps of all kinds, construction machinery, and power transmission equipment, a graduate engineer's chances for getting into his chosen field are even better.

"Supporting these divisions are research, engineering, production, purchasing, and sales, domestic and export. The real opportunity, however, is in Worthington itself. This is a company that is growing, just as it has for more than a century. It is always looking for new, related products and good men to engineer, produce, and sell them—at home and abroad.

"I began my career with Worthington's training program in the Research and Development Laboratory, where full-scale equipment is designed, tested and improved. This experience gave me an understanding of the tremendous part the company plays in the everyday life of millions of people. Within fourteen months I was sent to Mexico to inspect the facilities of our distributors there.

"The opportunities for first-hand laboratory experience, sales training and contact, travel and field trips, among many others, make Worthington a first-rate company for the young engineer with a desire to learn and progress in his work."

When you're thinking of a good job, think *high*—think *Worthington.*

8.26

FOR ADDITIONAL INFORMATION, see your College Placement Bureau, or write to the Personnel and Training Department, Worthington Corporation, Harrison, N. J.

WORTHINGTON

THE SIGN OF VALUE AROUND THE WORLD

This Month's Brain Teasers

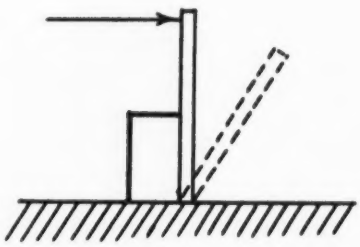
by BOB KANTOR

The CORNELL ENGINEER is offering three dollars to the first person who mails us the correct answers to all of the problems listed below. In general, the puzzles require very little paper work but a good deal of ingenuity. There are only two problems this month but both are quite tricky and should keep most people busy for awhile.

1. Approximately how many sets of integers satisfy the equation:

$$X^2 + Y^2 = 10{,}000$$

2. A rod is standing on a frictionless surface. There is a block to the left of the rod such that the rod cannot slip in that direction. If someone should tip the rod to the right so that it falls in the plane of the page, draw a series of pictures simulating those taken by a high



speed camera showing how the rod will look as it falls. Indicate a reference point.

Here are the solutions to two of the November puzzles.

1. The age problem did not prove to be too difficult. Practically all who submitted answers got it right.

Let X = man's age
Y = wife's age
Z = combined age of children at present
n = number of children

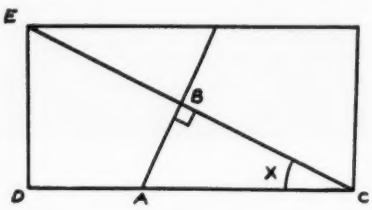
Then $X + Y = 6Z$

$X + Y - 4 = 10(Z - 2n)$

$X + Y + 12 = 3(Z + 6n)$

We can, from the first equation, find the value of X + Y. Substituting this value into the second and third equations gives us two linear equations with only two unknowns. We may then solve and find n = 3 children.

2. The only trick in this problem was in seeing that the crease is perpendicular to the diagonal of the paper and bisects it.



ED = 5
DC = 12
BC = 13/2
AB = P

△ EDC is similar to △ ABC

$$x = \text{Arctan}\ \frac{5}{12}$$

$$\frac{5}{12} = \frac{2P}{13}$$

$$P = \frac{65}{24}$$

$$\text{crease} = 2P = 5\ \frac{5}{12}$$

The third brain teaser in the November issue has aroused quite a bit of controversy. At present various plausible solutions are undergoing thorough scrutiny by the editorial board and the math department. A final solution will appear in the October ENGINEER.

● For many years K&E has pioneered in the manufacture and development of finest quality surveying instruments. K&E surveying instruments are renowned all over the world for their superb performance under conditions of all kinds, for their magnificent workmanship and for special features that come of progressive ingenuity.

KEUFFEL & ESSER CO.
EST. 1867
NEW YORK • HOBOKEN, N. J.
Chicago • St. Louis • Detroit • San Francisco • Los Angeles • Montreal

K+E
Drafting, Reproduction and Surveying Equipment and Materials, Slide Rules, Measuring Tapes.

teeth for a 1000 h.p. bite . . .

Undoubtedly you will recognize this application of a familiar technique for studying stresses. In this case, it was used to develop gears that are less than 5 inches in diameter yet easily transmit over 1000 horsepower.

Inherently, the design and development of aircraft engines offers unusual opportunities for applying basic engineering principles learned in school. In few other places can a technical graduate utilize his education and abilities more fully — gain recognition and advancement.

Many of our engineers who had important roles in developing the most powerful jet engine known to be in production — rated in the 10,000-pound thrust class — are still in their twenties.

To those young graduates who can see the career possibilities in the rapidly evolving field of aircraft propulsion, we can offer a real opportunity for growth and professional development.

PRATT & WHITNEY AIRCRAFT

Division of United Aircraft Corporation

East Hartford 8, Connecticut

put yourself in his place...

A year ago he was knee-deep in textbooks, plugging for his B.S. Tonight he's on his way to Vancouver, or Miami, or Portland, Maine. Tomorrow he'll help an Alcoa customer make a faster ship, a stronger shovel, a lighter highway trailer.

In Alcoa laboratories, plants and sales offices from coast-to-coast, ambitious young Sales Development Engineers are helping to make aluminum more useful, in more ways, to more people. We need more men just like them to help us meet ever-growing demands for Alcoa Aluminum . . . Alcoa "know-how".

Maybe you are already thinking about trading your textbooks for a position in production supervision, industrial research or sales engineering. Tell us about it, give us an idea of your background in Chemical, Electrical, Mechanical, Metallurgical or Industrial Engineering.

Good men go places fast with Alcoa, in their daily associations with leaders in the aluminum industry. Right now it may be quicker than you think from a seat in the classroom to your career with Alcoa. Why not find out?

Your Placement Director will be glad to make an appointment for you with our Personnel Representative. Or just send us an application, yourself.

ALUMINUM COMPANY OF AMERICA, 1825 Alcoa Building, Pittsburgh 19, Penna.

ALCOA **ALUMINUM**

ALUMINUM COMPANY OF AMERICA

ALCOA ON TV brings the world to your armchair with "SEE IT NOW" featuring Edward R. Murrow. Tuesday evenings on most CBS-TV stations.

Compatible color television will eventually reach every TV home

The rainbow you can see in black and white!

RCA brings you compatible color TV. Lets you see color programs in black and white on the set you now own!

"When a modern and practical color television system for the home is here, RCA will have it . . ."

Echoing down through the years, these words—spoken in 1946 by David Sarnoff, Chairman of the Board of RCA—have a ring of triumph today.

Behind this great development are long years of scientific research, hard work and financial risk. RCA scientists were engaged in research basically related to *color* television as far back as the 1920's . . . even before *black-and-white* television service was introduced.

Since then RCA has spent over $25,000,000 to add the reality of color to black-and-white TV, including development of the tri-color tube.

The fruit of this great investment is the RCA all-electronic compatible color television system, *a system that provides for the telecasting of high-quality color pictures that can be received in full color on color receivers; and in black and white on the set you now own.*

RCA and NBC will invest an additional $15,000,000 during color TV's "Introductory Year"—1954—to establish this new service on a solid foundation.

RCA color sets are beginning to come off the production lines in small quantities. Although it will probably be another year before mass production is reached, the promise of compatible color television is being fulfilled.

RCA pioneered and developed compatible color television

INTRIGUING OPPORTUNITIES FOR GRADUATING ENGINEERS

You're sure to find the exact type of challenge *you* want in Engineering Development, Design, or Manufacturing at RCA. Men with Bachelor's, Master's or Doctor's degrees in EE, ME, IE or Physics are needed. *You'll find your optimum career work* among the hundreds of products RCA produces for the home, science, industry and Government.

If you have the necessary education and experience, you will be considered for a direct engineering assignment. Otherwise, you'll participate in our Specialized Training Program, in which you can explore RCA's many interesting engineering operations for a full year.

Your rapid professional advancement is enhanced at RCA by the free flow of engineering information.

Write today to: College Relations, RCA Victor, Camden, New Jersey. Or, see your Placement Director.

RCA® *RADIO CORPORATION OF AMERICA*

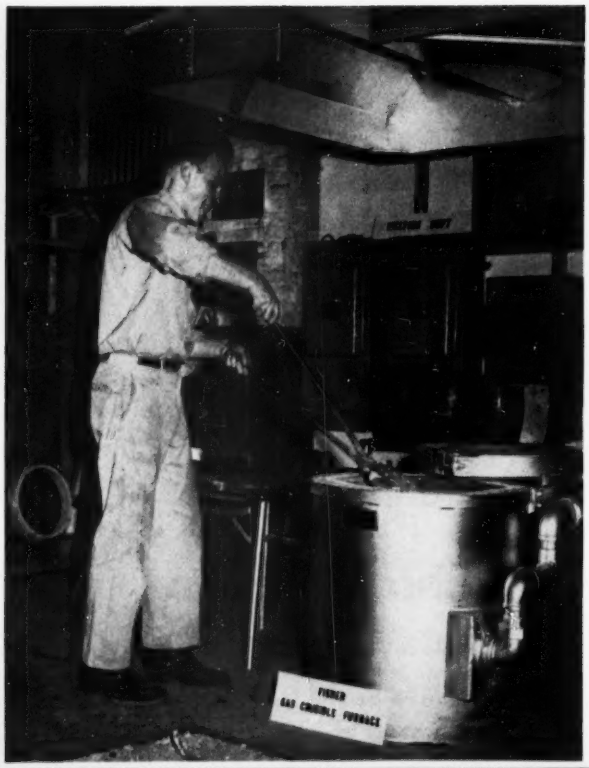
World leader in radio—first in television

ENGINE

April 3

Above—David Schriever (left) demonstrates the operation of an Olsen torsion testing machine to Susan Hoffmeister and David Findlay.

Below—One of many sub-frosh that visited Cornell for Engineers' Day looks on as an electronic calculator "blinks" through a problem. The Cornell Computing Center is located in Rand Hall.

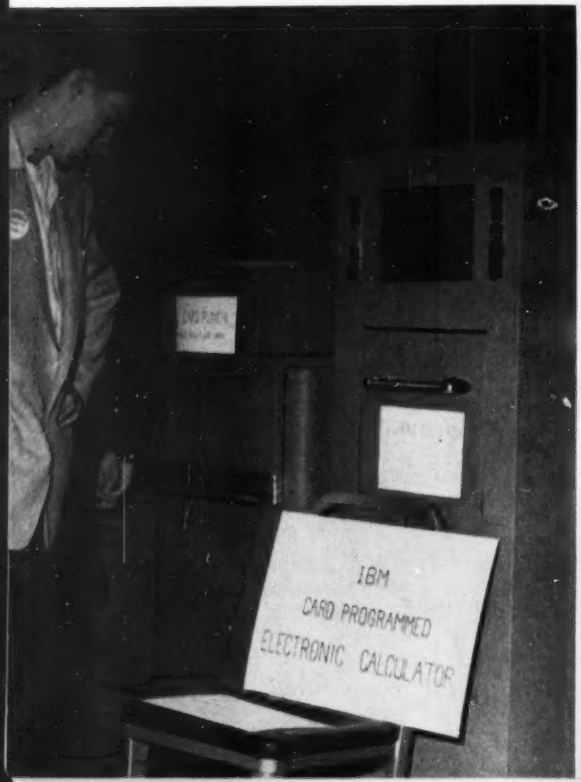


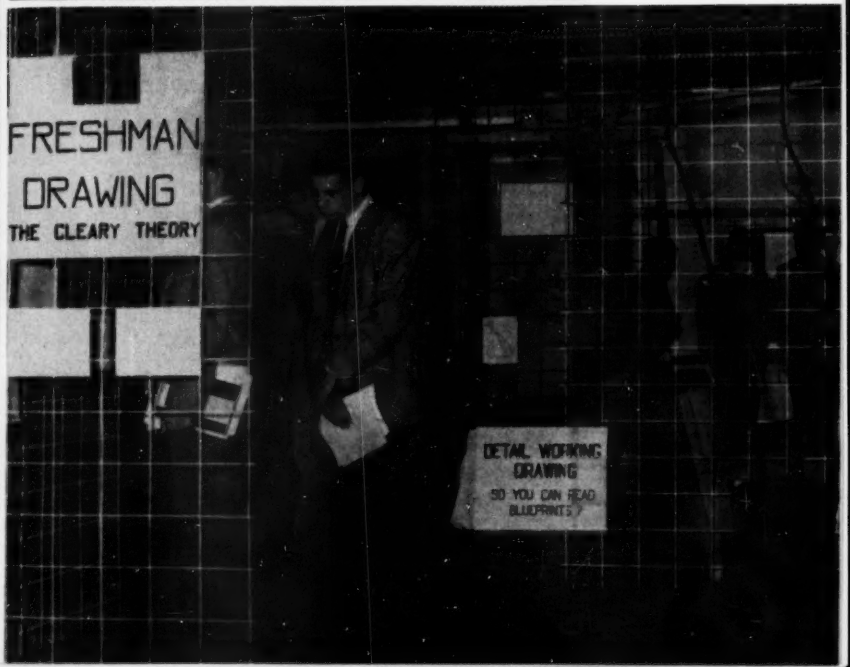
Left—Otto Eb drop
Aluminum into a ble fu
of the Metallurgi ngine
stration at the F .

Below left—A of
design and draft ispla
Lounge. Free r ment
lounge a popular with

Right—Ed Bar urns
of stock on an en the
machine tools ex in Ki
ton Hall.

Below right— rnell
ride on a Caterp Road
cated behind Li Hall
Damon Douglas i he co





ER DAY

, 1954

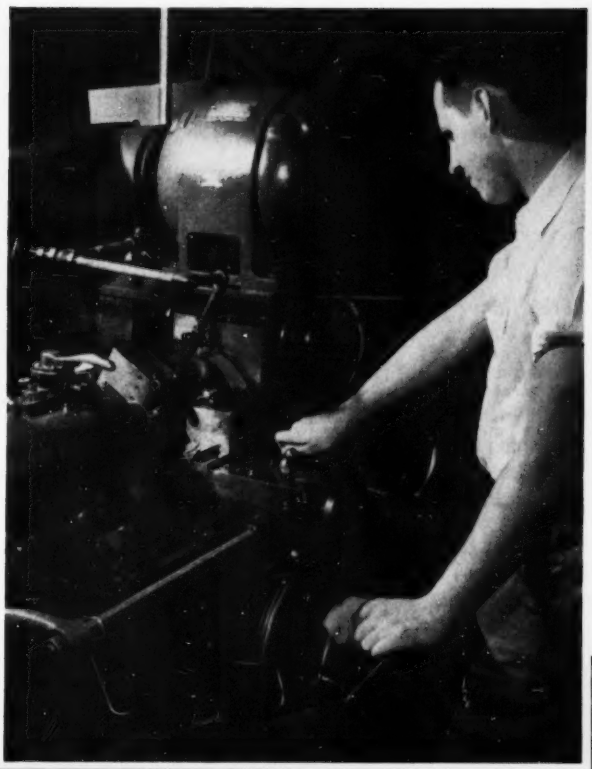
Photographs by Zelin, Starr, Glover

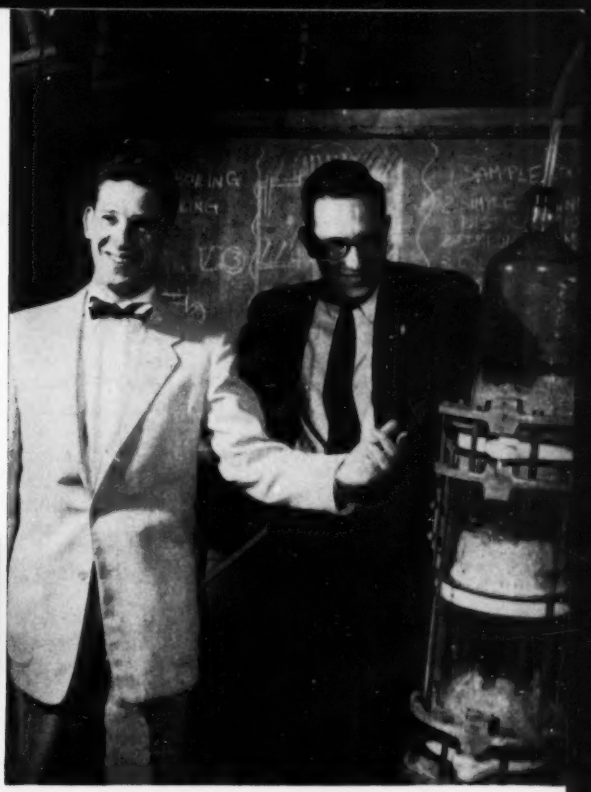
drops a bar of
ble furnace as part
ngineering demon-
y.

of visitors view
displays in Sibley
ments made the
with E-Day guests.

urns down a piece
uthe as part of the
in Kimball-Thurs-

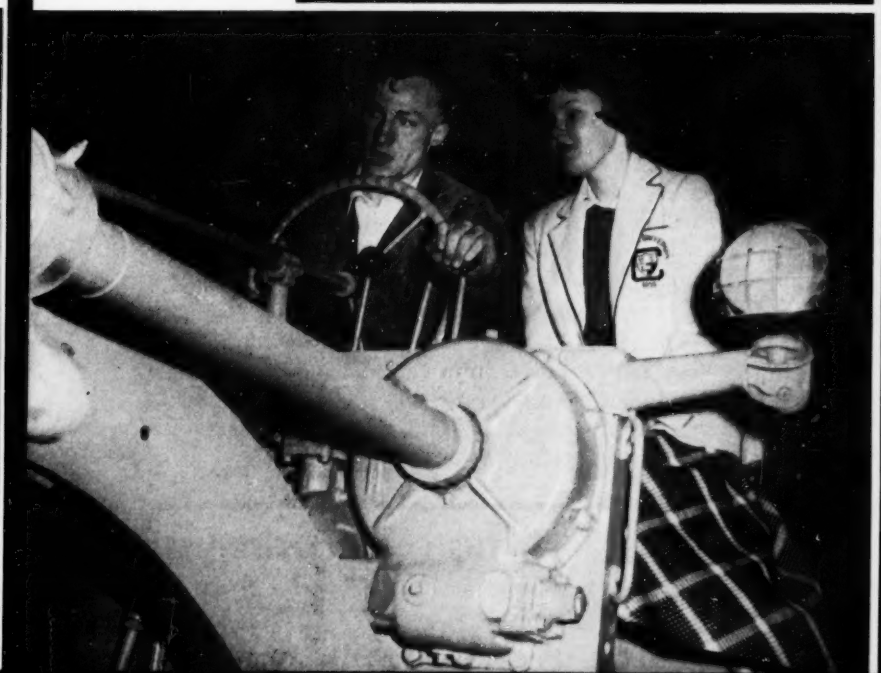
rnell coed gets a
Road Grader, lo-
Hall for E-Day.
he controls.

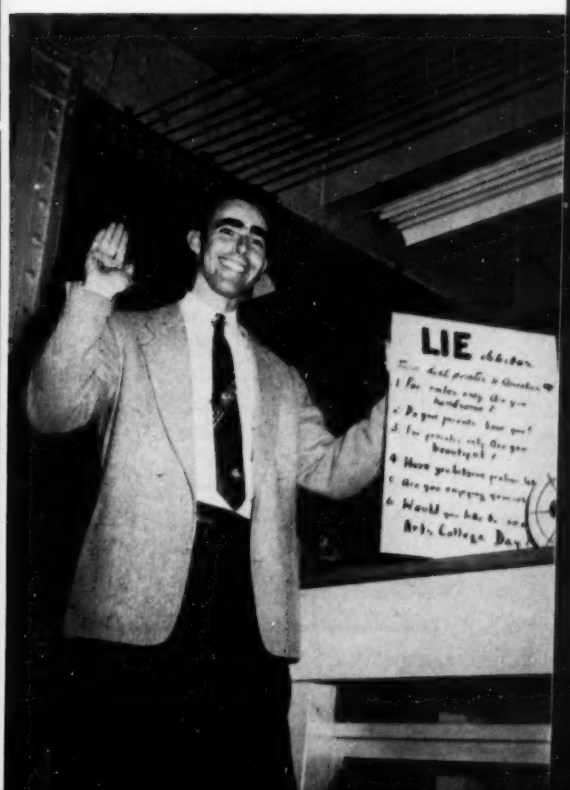




Above—Mike Mensha (left) and Lew Stone do a lot of explaining to visitors about the principle of fractional distillation as demonstrated with this distillation column.

Below—Paul Weisman swears to the accuracy of his Lie Detectac, one of the Electrical Engineering displays in Rand Hall.





CORNELL SOCIETY OF ENGINEERS

107 EAST 48TH STREET 1953-54 NEW YORK 17, N.Y.

THOMAS W. HOPPER, M.E. '28, *President* .....1700 Sansom St., Phila. 3, Pa.
WALTER M. BACON, E.E. '30 .....*Executive Vice-President*
510 East 84th St., New York 28, N. Y.
WALTER L. HARDY, Ch.E. '38 .....*Secretary-Treasurer*
421 East 20th St., New York 10, N. Y.
WILLIAM M. LEONARD, M.E. '24 .....*Recording Secretary*
4 Irving Pl., New York 3, N. Y.

Delaware Valley Branch
FRANK L. O'BRIEN, JR., M.E. '31, *Vice-Pres.* ....1545 N. Delaware Ave. Phila. 25, Pa.

New England Branch
J. RUSSELL CLARKE, JR., M.E. '26, *Vice-Pres.* .....Westford Rd., Concord, Mass.

New Jersey Branch
JOHN WEIKART, Ch.E. '42, *Vice-Pres.* .....714 Woodland Ave., Westfield, N. J.

Chicago Branch
FREDERICK H. BIRD, M.E. '11, *Vice-Pres.* .....1077 Westmoor Rd., Winnetka, Ill.

Detroit Branch
PHILIP J. KENT, M.E. '14, *Vice-Pres.* .....P.O. Box 1118, Detroit 31, Mich.

St. Louis Branch
ARTHUR J. LEUSSLER, M.E. '23, *Vice-Pres.* .....30 Rio Vista Dr., Clayton 5, Mo.

Honorary President: S. C. Hollister, Dean of the College of Engineering

Honorary Vice Presidents:
C. R. Burrows, Director of the School of Electrical Engineering
N. A. Christensen, Director of the School of Civil Engineering
H. J. Loberg, Director of the Sibley School of Mechanical Engineering
F. H. Rhodes, Director of the School of Chemical and Metallurgical Engineering
W. R. Sears, Director of the Graduate School of Aeronautical Engineering
L. P. Smith, Director of the Department of Engineering Physics

Thomas W. Hopper

"The objects of this Society are to promote the welfare of the College of Engineering at Cornell University, its graduates and former students and to establish closer relationship between the college and the alumni."

TO THE ENGINEERING GRADUATE

You have completed five years of intensive engineering education and are about to graduate from one of the finest universities in the world. No effort has been spared in giving you a rigorous training in engineering fundamentals, knowledge in specific fields, and a general cultural background from which to build your future careers. If these courses have been successful you will continue to grow intellectually and will develop for yourself an important place in business and general society. What you make of your life after graduation is up to you as an individual. You are on your own in the main stream of economic and social activities. We of the Cornell Society of Engineers have faith that you will carry on to the credit of the University, its Faculty and all of the Alumni.

Much advice is usually given to graduating classes and this is a good thing, because we are impressionable and perceptive at the commencement of new periods in our lives. You should receive this advice in good spirit and apply it to your best advantage. A simple rule is to be morally sound and mentally agile, not the other way around.

As one last message to you through this column, let me urge you to continue as engineers. Join and take an active part in technical societies such as A.S.M.E., A.S.C.E., A.I.E.E., and A.I.Ch.E. Become a registered professional engineer and a member of our own Cornell Society of Engineers. The engineering profession is not a restictive one and you can become president of a business concern, a leader in government, or an active participant in any legitimate activity, and at the same time remain an engineer in spirit and in thinking.

In the order of things today, the graduate engineer is Mr. Big. He is looked up to and recognized by business, government and the people in general. To warrant this leadership he should adopt professional ideals and standards which must be carefully maintained.

ALUMNI ENGINEERS

Charles P. Wood, M.E. '04, industrial engineer with Lockwood Greene Engineers, Inc., New York City, contributed the article on factory construction and planning in the current edition of Encyclopedia Britannica. His address is 410 East Fifty-seventh Street, New York City 22.

William Harry Blew, M.E. '09 died on July 19, 1953. His home was at 2339 Thackeray Drive, Oakland 11, Cal. Theta Chi.

Crosby Field, M.E. '12, president of Flakice Corp., Brooklyn, was awarded the annual medal of the American Society of Mechanical Engineers at a banquet in New York City last December. Field was cited for having "established and expanded industries and made invaluable contributions to improved designs and production techniques in many fields." His address is 8029 Harbor View Terrace, Brooklyn.

Ralph Allen, M.E. '13, 1 Ponce Road, Convent, N.J., December 11, 1953. He was assistant superintendent of power and telephone service with Western Electric Co., Kearny, N.J. Son, John W. Allen '43.

William R. Landmesser, M.E. '17, appointed by International Heater Co. of Utica as factory representative for the New York-New Jersey metropolitan area. His home is at 1496 Springfield Avenue, New Providence, N.J.

Marvin W. Wickham, M.E. '18, has been promoted to the post of supervising engineer of eastern engineering, Bell Telephone Co. of Pennsylvania. His address is 113 Redman Avenue, Haddonfield, N.J.

David S. Ramirez, M.E. '22, P.O.B. 9154, Santurce, Puerto Rico, is a consulting engineer for the manufacture of Portland cement in Puerto Rico and the Caribbean Islands. Ramirez resigned in 1950 as vice-president of Puerto Rico Industrial Development Co.

James N. Livermore, M.E. '34, was promoted to the position of assistant director of design engineering of Detroit Edison Co. Livermore was formerly a mechanical division engineer in the construction engineering department. He lives at 5 Hanover Road, Pleasant Ridge, Mich.

James N. Livermore

Henry N. Fairbanks, M.E. '28, 170 Penfield Road, Brighton, has been appointed assistant superintendent of research and development at Eastman Kodak Co., Rochester. He has been with the company since 1929 and for many years has been concerned with motion picture development work.

Whitford S. Wyman, M.E. '28, was appointed January 1, vice president of Dominion Oxygen Co., division of Union Carbide Canada Ltd., 805 Davenport Road, Toronto 4, Canada.

Howard M. Taylor, Jr., E.E. '29, 5414 Purlington Way, Baltimore 12, Md., has been elected chairman of the board of the Baltimore branch, Federal Reserve Bank of Richmond. He is president of International Bedding Co., Baltimore, Md.

Will H. Rowand, M.E. '30, and **James P. Tattersfield, M.E. '30,** attended an international, intercompany meeting held in Gleneagles, Scotland, by the worldwide Babcock & Wilcox organization. Rowand read several papers at the meeting, which included representatives from twenty-four countries. Rowand is vice-president in charge of engineering of Babcock & Wilcox Co., New York City, and lives at 38 Slope Drive, Short Hills, N.J. Tattersfield is president of Babcock & Wilcox de Mexico, S.A. de C.V., and can be reached at Apartado 21022, Mexico, D.F.

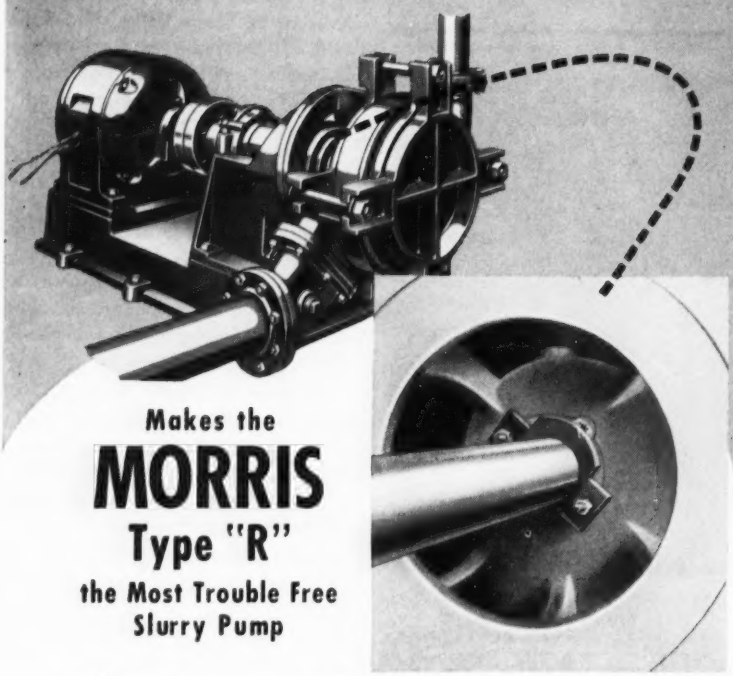
Bruce W. Hackstaff, C.E. '31, 27 West Neck Road, Huntington, has been appointed director of the department of plant and production for F. & M. Schaefer Brewing Co., Brooklyn. He was manager of the engineering department since 1950 and packaging manager since 1952.

William E. Neff, M.E. '33, was transferred last July from "Ducilo" S.A., Buenos Aaires, Argentina, to the du Pont Cellophane plant in Clinton, Iowa, where he is technical superintendent.

John Hammond, C.E. '35, was recently named to head the new Marine Division of the Sperry Gyroscope Co., to be located at Roosevelt Field, L.I. He has gained widely varied experience in sales, planning, pricing, manufacturing, and field engineering since joining Sperry in 1940. He has served as shop superintendent, manager of Navy contracts, director of field service engineering, and director of commercial sales. As manager of the new facility, he will direct the entire operation of the Marine Division plant as an integral autonomous unit physically separate from the main Lake Success plant.

John Hammond

Stuffing Box Under Suction Pressure Only...



Makes the

MORRIS

Type "R"

the Most Trouble Free Slurry Pump

This is the pump with the deep stuffing box under suction pressure only. Entrance of grit into stuffing box is minimized —slurry dilution from stuffing box leakage negligible. The pump requires only nominal sealing water pressure, yet can operate under high vacuum as well as high suction heads. Because of this design, stuffing box troubles are practically eliminated.

"The Morris Type R is built for handling refuse, sludge, chemicals in suspension, tailings, concentrates, coal, ore—any liquid containing abrasive solids. For long term efficiency and economy, for a minimum of maintenance and shutdowns—specify Morris Type R Slurry Pump."

MORRIS
MACHINE WORKS
Baldwinsville, N.Y.
"Offices in Principal Cities"

FREE TECHNICAL SERVICE

Free technical consultation with Morris engineers at your request. For further information write today for Bulletin #181.

MORRIS *Centrifugal Pumps*

Charles W. Lake, Jr., B.S. in A.E. (M.E.) '41, 420 Stone Avenue, La Grange, Ill., has been elected vice-president of R. R. Donnelly & Sons Co., Chicago, Ill.

B. Emerson Cole, B.S. in A.E. (M.E.) '41, 74 Stanton Road, Darien. Conn., is a television writer with the advertising firm of Sherman & Marquette, Inc., 10 Rockefeller Plaza, New York City 20. He recently returned from Hollywood, Cal., where he spent five weeks working on the Colgate Comedy Hour.

Stephen D. Teetor, B.C.E. '43, has become an Associate of Seelye Stevenson Value & Knecht in charge of Foundations, Soil Mechanics, Inspection and Research.

James G. McMillan, Jr., Chem.E. '46, is a chemical engineer at Hercules Powder Co., Parlin, N. J. He and his wife and their small daughter live at 14 Manor Drive, Red Bank, N. J.

Max R. Bluntschli, M.E. '47, 6030 Sheridan Road, Apt. 2009, Chicago 40, Ill., is an engineer with Corsoer, Townsend & Associates, consulting engineers, and has passed his examinations for registration as a professional engineer in Illinois.

Lucius W. Johnson, Jr., B.Arch. '49, 1276 Alexandria Drive, San Diego 7, Cal., is an architectural draftsman with the firm of Paderewski, Mitchell & Dean and has passed eight-ninths of his examination for an architect's license.

William W. Koch, B.Chem.E. '49, and Mrs. Koch announce the birth of a son on January 12. They live at 21 St. Clair Avenue, Rutherford, N.J.

William A. Koch, E.E. '49, 1714 Meadow Lane, East Meadow, is supervising traffic equipment with New York Telephone Co. He is married and has two sons.

John D. Gernon, Chem.E. '51, 301 Beattie Avenue, Apartment 4, Lockport, resigned from National Advisory Committee for Aeronautics to join process study group of Hooker Electrochemical Co., Niagara Falls.

Russ Schuh, Chem.E. '52 of shot put fame, is a chemical engineer with du Pont at Niagara Falls, where he lives at 2446 Pierce Ave.

The metal that thrives on punishment

Steel serves you better when manganese is added
—because the harder it works, the tougher it gets

EVER WATCH a power shovel bite into earth and rock? And wonder how the teeth of the steel bucket can endure such punishment? The amazing answer is that the teeth not only endure such treatment—they actually get harder because of it!

MANGANESE HOLDS THE SECRET—The story behind this remarkable steel is the unusual metal called *manganese*. The hundreds of thousands of tons of manganese required each year by steel and other metal-making industries are obtained by refining huge quantities of ore that come from mines in widely scattered points across the face of the globe.

ADDED TO STEEL—All steel contains manganese. A small amount "cleanses" molten steel and removes impurities. A larger amount of manganese makes the steel tougher and stronger.

FROM ORE TO ALLOY—Transforming raw ores into a variety of manganese alloys for the metal-producing industries is one of the many important jobs of the people of Union Carbide.

STUDENTS AND STUDENT ADVISERS: *Learn more about career opportunities with Union Carbide in* ALLOYS, CARBONS, CHEMICALS, GASES, *and* PLASTICS. *Write for booklet C-2.*

UNION CARBIDE
AND CARBON CORPORATION
30 EAST 42ND STREET UCC NEW YORK 17, N. Y.
In Canada: UNION CARBIDE CANADA LIMITED

UCC's Trade-marked Products include

ELECTROMET Alloys and Metals
HAYNES STELLITE Alloys
UNION Carbide
NATIONAL Carbons
ACHESON Electrodes
PYROFAX Gas
PREST-O-LITE Acetylene
PRESTONE Anti-Freeze
EVEREADY Flashlights and Batteries
BAKELITE, VINYLITE, and KRENE Plastics
SYNTHETIC ORGANIC CHEMICALS
DYNEL Textile Fibers
LINDE Oxygen

College News

Charles E. Colbert, a fifth-year student in Cornell's School of Electrical Engineering, received a first prize of $25 in a contest sponsored by the Ithaca section of the American Institute of Electrical Engineers.

Finalists in the annual contest presented papers at the section's March meeting at Cornell on March 12. The winning paper was on "Capacitance Speed Control for a Crane Hoist Drive Motor."

Colbert represented the Ithaca section in a similar contest at the northeastern district meeting of AIEE in Schenectady on May 5-7.

Second and third prizes of $20 and $15 were won, respectively, by George T. Kramer, for a paper on "Non-destructive Read-out of Digital Information Stored in Magnetic Cores;" and by Robert E. Flory, who discussed "Carrier Synchronization of Radio Broadcast Stations."

All three winners expect to receive Bachelor of Electrical Engineering degrees in June.

Thurston Hall Displays

Exhibits of products and manufacturing techniques of modern industry have been featured in displays in Thurston Hall, Cornell's Mechanics and Materials Department building. Housed in four six-foot-square show cases, and supplemented by descriptive pamphlets and brochures, exhibits have illustrated a variety of scientific and engineering developments.

The most recent exhibit shows the manufacture of a variety of athletic equipment. The Cortland Racket Division of the Cortland Line Company illustrated all of the steps in the construction of tennis, squash, and badminton rackets. The display showed how wood for use in rackets is dyed, so that if the racket is scuffed or chipped the color is retained. A unique feature of the Cortland manufacturing process is the use of radio-frequency bonding of laminated parts. The radio frequency method, comparable to induction heating, provides instant heating throughout the material, reducing time for the gluing process to about a minute. Other processes require much longer gluing periods, and the use of shape-retaining jigs while the glue is setting. Holes for stringing are automatically drilled by specially designed air-operated machines.

The Wilson Sporting Goods Company presented the steps in the construction of a baseball, from its cushion cork center, to its final finishing and cementing after four separate windings. Another part of the display featured the manufacture of both wood and iron golf club heads.

In the near future, the Cornell Aeronautical Laboratory will present an exhibit illustrating its varied research activities. The exhibit will include a 1/30th-scale model of the Laboratory's variable-density wind tunnel. The tunnel itself requires 12,000 horsepower for its operation, and is used for testing air-

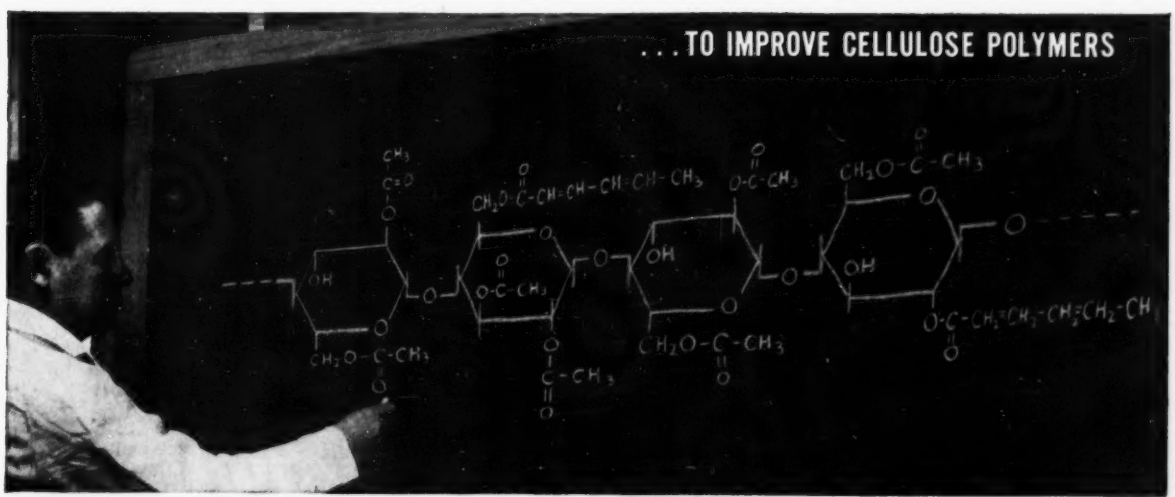
This display by the Cortland Line and Cord Company shows step-by-step construction of tennis and badminton rackets.

—Photo Science

A new Hercules plant under construction at Burlington, New Jersey, will make the essential raw material for Canadian production of 'Terylene'—polyester yarn. Known as dimethyl terephthalate, or DMT, this basic chemical for polyester fibers will be made by an entirely new process, and will be available eventually for plastics and other uses.

HOW HERCULES HELPS...

Hercules' business today helps almost everyone's business. It embraces the production of synthetic resins, cellulose products, chemical cotton, terpene chemicals, rosin and rosin derivatives, chlorinated products, and many other chemical processing materials—as well as explosives. Through close cooperative research with its customers, Hercules has helped improve the processing or performance of many industrial and consumer products.



Hercules now offers Hercose®S (cellulose acetate sorbate), a new film-former. Widely soluble, it can be applied as tough, flexible coatings and cured to insoluble condition. Hercose S films have excellent resistance to heat and low temperatures. It is another in the diverse group of Hercules cellulose chemicals offered many industries. Write for details.

HERCULES

HERCULES POWDER COMPANY Wilmington 99, Delaware

EC54-4

LAVA

Manufacturers of Super-Refractories Only

REFRACTORY CRUCIBLES
GRAPHITE CRUCIBLES
HIGH-TEMPERATURE CEMENTS
SPECIAL REFRACTORY BRICK, TILE, SHAPES

From the Following Materials:—

GRAPHITE —— SILICON CARBIDE —— FUSED ALUMINA —— MULLITE
MAGNESIA ZIRCON

LAVA CRUCIBLE-REFRACTORIES CO.
PITTSBURGH, PA.

craft, missiles, and propellers at speeds ranging from 50 to 700 miles per hour. Tunnel modifications permit testing in the transonic and supersonic speed ranges. In addition, the display will present specimens of recent developments in materials, including high-temperature metals, plastic structural parts, and energy-absorbing paddings. An array of photographs will illustrate the Laboratory's technical program covering a variety of aeronautical and related research fields. Photos will also show the Cornell Aeronautical Laboratory's participation in education, including the Cornell Co-op plan.

ASCE Meeting Hears National President

Daniel V. Terrell, dean of the College of Engineering at the University of Kentucky and national president of the American Society of Civil Engineers, spoke at the March dinner meeting of the ASCE Ithaca section on Thursday (March 18) at 6:30 p.m. in the Statler Inn at Cornell.

Three Cornell faculty members received life membership certificates in the ASCE at this meeting: Dean S. C. Hollister of the College of Engineering and John E. Perry and Paul H. Underwood, professors emeritus of civil engineering.

Dean Terrel, noted for his highway research, has been highway authority on many state and federal bodies and since 1942 has headed the Kentucky State Highway Research Laboratory.

He graduated from the University of Kentucky in 1910, has been on its faculty since 1912, and in 1927 helped to consolidate three separate units into its College of Engineering.

He is a charter member and former president of the Kentucky section of the ASCE and organized the student chapter at his university. He is also a past president of the Kentucky Society for Professional Engineers.

Cornell Elects Two Trustees

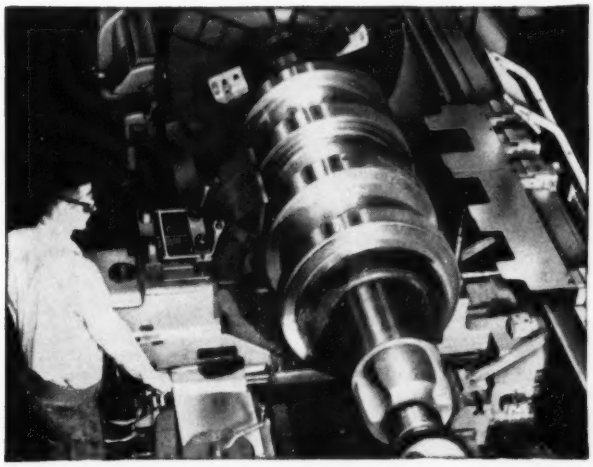
John P. Levis, president of Owens-Illinois Glass Company, and John M. Olin, president of Olin Industries, Inc., were elected to the Cornell University Board of Trustees. Both are Cornell graduates.

Mr. Levis will serve until 1955 and Mr. Olin until 1956. Respectively, they succeed the late Thomas W. Pew of Houston, Texas, and the late Robert E. Treman of Ithaca. Mr. Levis, of Toledo, received the degree of mechanical engineer in 1924. He joined Owens-Illinois in 1929 and has been president of the firm since 1941.

Mr. Olin, whose home is in Alton, Ill., was with Western Cartridge Company from 1913 to 1944. He became president of Olin Industries in 1945 upon the retirement of his father, Franklin W. Olin, alumnus, university benefactor and a member of the Cornell board for 17 years until his death in 1951.

He entered Cornell from Cascadilla School and received the bachelor of chemistry degree in 1913. Olin Hall of Chemical and Metallurgical Engineering is named for his brother, the late Franklin W. Olin, Jr., class of 1912, and F. W. Olin Olin Hall, the new medical college residence under construction in

Another page for **YOUR BEARING NOTEBOOK**

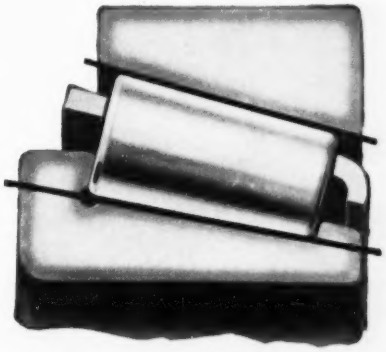


How to hold a heavily-loaded lathe spindle in accurate alignment

This big lathe machines rolls for steel mills. The roll is rotated by the lathe spindle and it must be machined to very accurate dimensions. So the lathe manufacturer, LeBlond Machine Tool Company, mounts the spindle on Timken® tapered roller bearings. Despite the great weight on the spindle, the Timken bearings hold it precisely in place—because they are made so accurately and have such high load capacity.

Why TIMKEN® bearings have high load capacity

This picture shows why Timken bearings have such high capacity—the load is carried on a *full line contact* between the rollers and races in the bearing. Note also the tapered construction. This permits the bearing to be tightened up (preloaded, we call it) to prevent chatter in rotating parts like the machine tool spindle above.



TIMKEN
TRADE-MARK REG. U. S. PAT. OFF.
TAPERED ROLLER BEARINGS

Want to learn more about bearings or job opportunities?

Some of the engineering problems you'll face after graduation will involve bearing applications. For help in learning more about bearings, write for the 270-page General Information Manual on Timken bearings. And for information about the excellent job opportunities at the Timken Company, write for a copy of "This Is Timken". The Timken Roller Bearing Company, Canton 6, Ohio.

NOT JUST A BALL ○ NOT JUST A ROLLER ⬭ THE TIMKEN TAPERED ROLLER ⬭ BEARING TAKES RADIAL ⓞ AND THRUST —ⓞ— LOADS OR ANY COMBINATION ✳

Welded Steel Designs Cost Less because:

1. Steel is 3 times stronger than gray iron.
2. Steel is 2½ times as rigid.
3. Steel costs a third of iron.

Ultimate savings are limited only by the ingenuity of the designer.

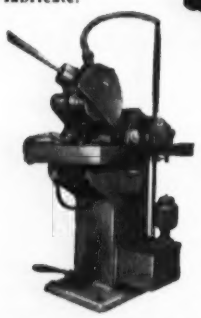
SIMPLIFIES DESIGN CUTS FABRICATING COSTS WITH WELDED STEEL

The successful industrial designer is one who can suggest ways of cutting the costs. That's why the engineer who knows how to utilize savings through welded steel finds his designs readily accepted.

Here, for example, is how steel design has eliminated 356 pounds of metal in the manufacture of the base for this machine. All former machining has been eliminated. There are no bolted joints to cause leakage of coolant. Cost of manufacture has been cut 20%.

First redesign to steel . . . weighed 764 pounds. Required only 31 hours to fabricate.

Final design more compact in construction, weighs 692 pounds . . . takes less floor space, requires only 24 hours to fabricate.



Original design required 1048 lbs. of castings bolted together. Each casting required costly machining and fitting.

HOW TO PUT STEEL'S SAVINGS TO WORK—
DESIGN DATA for welded construction is available to engineering students in the form of bulletins and handbooks. Write:

THE LINCOLN ELECTRIC COMPANY
Cleveland 17, Ohio
THE WORLD'S LARGEST MANUFACTURER OF ARC WELDING EQUIPMENT

—*Sol Goldberg*

The Solatron's builder, Robert M. Matyas, demonstrates its operation to John M. Vatet and Prof. Frederick W. Edmondson, designer of the apparatus.

New York City, honors his father. He is a brother of Spencer T. Olin, class of 1921.

Cornell Develops Model Sun

Cornell's College of Architecture has a new version of the sun lamp—a "solatron" for simulating the position of the sun for any latitude, season and time of day.

Its strong electric light shines on small-scale architectural models at the same angle as the sun will shine on the actual buildings.

The college said architects could use the solatron for designing sun control devices, for visualizing the sun's effect on housing projects and buildings, and for solving other problems.

The solatron can show, for example, exactly how overhanging roofs can cut off the direct rays of the high summer sun but permit the winter sun's low rays to penetrate a house.

The device has two parts—a table with a circular revolving top marked in 360 degrees, and a quarter-circle graduated metal framework, on which the lamp moves by means of a crank-operated pulley and cable.

Positions of the table top and the lamp are determined for each test from a simple computing device. After the architectural model is set on the table at the proper latitude, the lamp is placed at the proper angle—the sun's angle above the horizon—for any time of the year or any hour of the day.

The solatron was designed by Prof. Frederick W. Edmondson, who teaches landscape architecture. It was built by Robert M. Matyas, an architecture graduate who is synchrotron engineer in the Cornell nuclear studies laboratory.

EP School Offers Course In Electron Microscopy

Director Lloyd P. Smith of the Department of Engineering Physics announces that the annual Cornell Summer Laboratory Course in Techniques and Appliancations of

Foreground: Boeing RB-47E, world's fastest day-or-night long-range reconnaissance plane. *Background:* Standard B-47E six-jet bomber.

What do you want most in an engineering career?

Is it room to grow? Then join a company that's *growing*. Boeing, for example, has grown continuously throughout its 37-year history of design, production and research leadership. There's always room up ahead—and Boeing promotes from within. Regular merit reviews are held to give you steady recognition.

Do you want long-range career stability? Boeing today employs *more* engineers than even at the peak of World War II. Here you'd work on such projects as pilotless aircraft, research on supersonic flight and nuclear power for airplanes, on America's first jet transport, and the world's outstanding jet bombers.

Do you want variety of opportunity? Aviation is unique in this respect. It offers you unmatched variety and breadth of application, from applied research to production design, all going on at once. Boeing is constantly alert to new materials and new techniques, and approaches them without limitations. In addition, Boeing's huge subcontracting program—requiring engineering co-ordination—offers you contacts with a cross section of American industry.

Boeing engineering activity is concentrated at Seattle, Washington, and Wichita, Kansas—communities with a wide range of recreational opportunities as well as schools of higher learning. The company will arrange a reduced work week to permit time for graduate study and will also reimburse tuition upon successful completion of each quarter's work.

There are openings in *all* branches of engineering (mechanical, civil, electrical, aeronautical and related fields) for DESIGN, PRODUCTION and RESEARCH. Also for physicists and mathematicians with advanced degrees.

For further information, consult your PLACEMENT OFFICE, or write

JOHN C. SANDERS, Staff Engineer — Personnel
Boeing Airplane Company, Seattle 14, Wash.

BOEING

the Electron Microscope will be given from June 14 to June 26, 1954, by the department's laboratory of Electron Microscopy. The course under the direction of Dr. Benjamin M. Siegal will have Dr. James Hillier of Melpar, Inc., Alexandria, Virginia, and Dr. C. E. Hall of M.I.T., Cambridge, Massachusetts, as guest lecturers this year.

The course is designed for those research workers, institutional and industrial, who have recently entered the field of electron microscopy or who are now planning to undertake research problems involving applications of this instrument. Further inquiries should be addressed to Dr. Benjamin M. Siegel, Department of Engineering Physics, Rockefeller Hall, Cornell University, Ithaca, N.Y.

Cornell Exhibits Model Kitchen

The Cornell Model Kitchen, on display as a part of this year's Farm and Home Week program, reveals the newest trends in engineering design for the modern homemaker. Although specifically constructed for rural use, the kitchen previews prefabrication methods adaptable to mass-production assembly. The Model Kitchen represents seven years of development by the University's Housing Research Center, in which Home economists, sociologists and engineers cooperated to create cooking facilities tailored to meet the specific needs of individual housewives.

The kitchen is composed of independent units, each providing necessary space and equipment for the steps in the preparation of meals. There is the service center, the range, mix center, sink center, oven center, and refrigerator center, each containing its own electric wiring and plumbing. These units are separate, free-standing structures, and may be moved to form straight line, u-shaped, or any desirable kitchen arrangement for any combination of windows and doors. The units are completely collapsible, and can be transported by disconnecting the various component-panels.

The basic structure of each unit is a c-frame side piece, to which is connected towboard and base members providing a framework for desired equipment. This built-up design allows the kitchen units to be shipped flat and assembled on the spot. To meet mass production requirements, the units have been designed with a two-foot modulus, each having an overall length of four feet and two-foot wide cabinet doors. Aluminum is used as the main construction material, to which white enamel has been applied by an electrical "polyclutching" process. Counter tops are made of a fused mineral plastic, Korok, which is harder than formica.

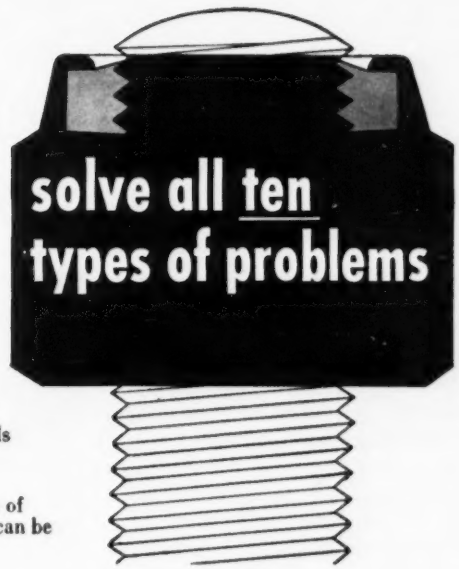
To suit the individual homemaker, counter-top height is easily adjustable by the addition of spacers. Doors slide into the cabinet proper, making open cabinets easily accessible. Shelves inside the cabinets slide out and are adjustable in height. Cabinets above the counters for dishes are wider at the top than near the counter itself, providing more working area without reducing storage capacity. Range burners are built into the counter-top of the range unit, and the oven is at eye level. A space is available above the eight-cubic-foot refrigerator for an additional freezer.

Other design improvements that add to the Model Kitchen's convenience and efficiency include a built-in dishwasher, a garbage container unit mounted on a frame that swings into a cabinet when not in use, a mixer-type faucet that provides water at any desired temperature by the adjustment of a single handle, a built-in flour sifter with a telescoping handle, and a ventilating towel-storage and drying rack. The Model Kitchen, combining study in home management, social psychology, engineering, and project design and utilizing time and motion study, is being operationally tested in five separate rural-home installations.

Other Farm and Home Week exhibits of engineering interest included a display of building material applications, illustrating foundation types, wall sections, and insulation materials. Modern agricultural machinery, such as air-blast crop sprayers, hay blowers, field loaders, tractors, and combines were shown in the Agricultural Engineering Teaching Laboratory.

MASTERS of PRODUCTION
. . . in the toolroom, on the production line, or in the inspection department.
Brown & Sharpe Machine Tools and Small Tools are the masters that fulfill today's industrial demands for consistently accurate work. Throughout metal-working shops the world over, these products are recognized as standards for precision work.
For information on this famous line of Milling, Grinding and Screw Machines, Machinists' Tools, Electronic Measuring Equipment, Jo-Blocks, Cutters, Permanent Magnet Chucks, Pumps and Vises write Brown & Sharpe Mfg. Co., Providence 1, Rhode Island, U.S.A.
Brown & Sharpe

elastic stop nuts solve all ten types of problems

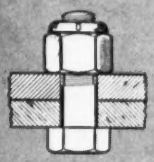


Here are ten typical fastening problems. One device, the ELASTIC STOP nut, solves them all—without additional parts or operations. Deliberately undersized in relation to bolt diameter, the red elastic collar grips the bolt with a perfect fit, exerting a continuing self-locking pressure against the threads, and holding the nut securely in place at any point on the bolt. It also provides a tight seal against the bolt threads, which prevents seepage and wear-producing axial play. And because the bolt threads are protected against moisture from without, the nuts are not "frozen" to the bolt by corrosion.

ELASTIC STOP nuts stay tight, right where you put them, in spite of vibration and stress reversals. Yet they are not jammed in place, and can be removed with a wrench and reused many times.

For further information on ESNA self-locking fasteners, mail the coupon below.

TIGHTENED AGAINST THE WORK



Wherever a vibration or impact proof bolted connection is desired.

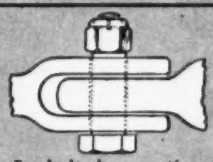
On all electrical terminals subjected to vibration in transit or operation.

For uniform and precise prestressing of multiple bolt assemblies . . . adjusted by predetermined wrench torques.

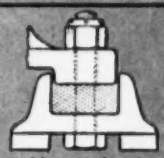
LOCATED ANYWHERE ON THE BOLT

Spring-mounted connections or dynamic balancing, where nut must stay put yet be easily adjusted.

On make-and-break adjustment studs where accurate contact gaps are required.

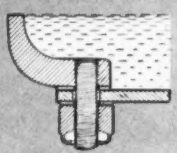


For bolted connections requiring predetermined play.

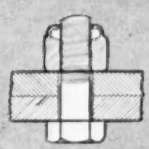


For rubber-insulated and cushion mountings where the nut must not work up or down.

FOR MANY SPECIAL APPLICATIONS



To seal bolt threads where elimination of leakage past stud threads is necessary.



To seal bolt threads where it is necessary to protect them from corroding elements.

To obtain delicate adjustments for applications such as bearing locknuts where precise adjustment is essential.

ELASTIC STOP NUT CORPORATION OF AMERICA

ESNA TRADE MARK

ROLLPIN TRADEMARK

Dept. N40 , Elastic Stop Nut Corporation of America
2330 Vauxhall Road, Union, New Jersey

Please send the following free fastening information

☐ Elastic Stop nut bulletin ☐ Here is a drawing of our product. What self-locking fastener would you suggest?
☐ Rollpin bulletin

Name_____ Title_____

Firm_____

Street_____

City_____ Zone_____ State_____

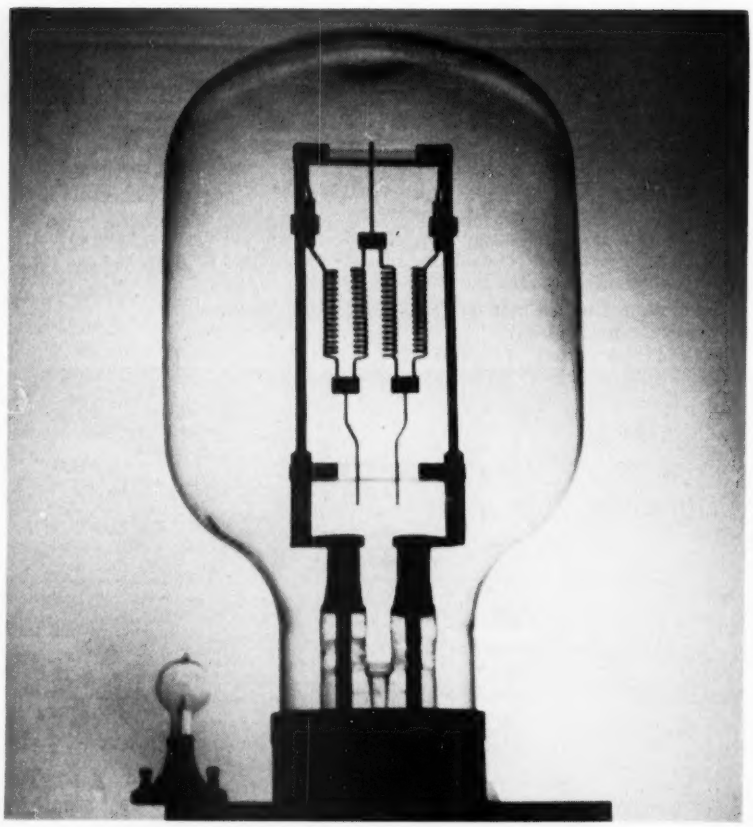
Technibriefs

General Electric announces that it has developed and produced the world's largest artificial light source, a 75,000 watt incandescent light bulb. Its glass bulb, largest ever made, was hand blown by the Corning Glass Company, first producer of bulbs for Edison.

The lamp produces 2,400,000 lumens. To produce this amount of light would require 2,874 60-watt household bulbs, all burning simultaneously. This single light bulb uses enough electric energy to light 83 American homes as they are normally lighted today. The lamp's filament weighs 2.7 pounds, using enough tungsten to make the coiled-coil filaments for 67,500 60-watt lamps. The filament is made of a tungsten ingot, hammered to a diameter of three-sixteenths of an inch. It is 12 and one-half feet long.

The huge lamp is so bright and hot that observers are advised not to look directly at it or stand close to it when it is burning at full brilliance.

The first practical incandescent lamp was invented by Edison just 75 years ago next October 21. By today's standards it was inefficient light source, producing only 1.4 lumens per watt of electricity consumed. In contrast, the 75,000-watt bulb gives out 32 lumens per watt, and is one of the most efficient incandescent light sources yet produced.



The newly developed General Electric light bulb, the world's largest, is shown here alongside a replica of Edison's first incandescent lamp.

Rare-earth Element Studied at Oak Ridge

The natural isotopes of the rare-earth element, gadolinium, are being separated for the first time in a mass spectrograph, or calutron, be- Oak Ridge National Laboratory, according to an announcement made by C. P. Keim, head of the Stable Isotope Research and Production Division. The calutron is an adaptation of equipment used during World War II for separating U-235 by the electromagnetic process.

Isotopes of gadolinium are separated by heating gadolinium chloride to about 1500 degrees Fahrenheit, decomposing the molecules and converting the gadolinium atoms to positively charged ions by bombardment with electrons of a few hundred volts energy, accelerating these ions by an electric field of about 35,000 volts so as to propel them across a magnetic field where they are constrained by the field to a circular path of travel. The radii of travel of the isotopes are proportional to the isotope weight. After these isotopes ions have gone half-way around the circle they are captured in collectors placed at such positions to intercept the isotopes of different weights.

The uses for gadolinium are for the most part undeveloped because, like most other elements of the rare-earth group, gadolinium has not been available in adequate amounts to researchers for extensive study. The preparation of pound quantities of pure gadolinium by enrichment of its isotopes by the the isotope chemists as well as the calutron specialists will provide gadolinium forms for widespread research. Gadolinium is of great interest in the field of nuclear physics because some of its isotopes have extremely high absorption cross sections for neutrons. Even valuable new radioisotopes may result from the use of separated stable isotopes

Ever Study

TERRESTRIAL ENGINEERING?

Probably not. As far as we know, there isn't such a term. Even so, the terrain of a manufacturing plant may have a vital effect on the design and location of its engineering equipment.

It certainly did in the case of our Belle, West Virginia, plant, which is just across the road from a flat-topped hill, 750 feet high.

Perhaps you'd like to match wits with Du Pont engineers, for we feel that this problem was interesting—and its solution ingenious.

Briefly, the situation was this: Carbon dioxide was to be removed from a mixture of gases by bringing them into contact with water in "scrubbers" operating at 450 psi (gauge). The inlet gases contained about 25% CO_2 by volume. Because of its greater solubility, most of the CO_2 would leave the scrubbers dissolved in the water.

It was necessary to reduce the pressure of this water to atmospheric and recover the dissolved carbon dioxide, since CC_2 was needed for use in a chemical synthesis. The degasified water then had to be pumped back into the pressure scrubbers, to repeat the scrubbing cycle.

Still like to match wits? How would you design an economical closed system for this scrubbing water? After you've thought out your solution, you might like to compare it with the one given below.

Du Pont engineers made use of the precipitous terrain in this way: pressure on the water leaving the scrubbers was sufficient to force it up to the top of the hill for CO_2 recovery. The returning water thereby provided a pressure of approximately 325 psi (750 feet of head) at the base of the hill. This gift of pressure on the suction side of the water pumps resulted in considerable energy saving.

Do unusual problems such as this one challenge you and stir your enthusiasm? If they do, we think you'll be interested in technical work with the Du Pont Company.

Watch "Cavalcade of America" on television

DU PONT

REG. U.S. PAT. OFF.

E. I. du Pont de Nemours & Company (Inc.)

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

as starting materials in the pile or cyclotron.

Gadolinium is the fourth rare earth that has had its isotopes separated at Oak Ridge National Laboratory; cerium, neodymium, and samarium have been previously processed. It now appears that steady progress will be made in the successful separation of purer forms of rare-earth isotopes.

New Device Sorts Metal Parts

A fast, accurate non-destructive instrument for sorting mixed metal parts with varying alloy content has been developed by General Motors Research Laboratories.

Known as the Thermoelectric Metal Comparator, the instrument is a portable device, easy to operate in any surroundings and usable wherever troubleshooting is necessary to distinguish one part from another with composition the only distinguishable feature.

In plants, warehouses or other storage areas where bar stock or parts shipments have been scrambled inadvertently, the comparator is expected to be a key device in restoring order or reclassifying materials.

The comparator also can detect chills in castings, which cause hardness differences. At the same time, favorable results have been obtained by using it to measure thickness of paint films and metallic plating. Further investigation is under way.

In its tryout stage, the comparator was used in several General Motors divisions for such jobs as these:

1. Sorting a stock of mixed steel in which SAE 1112 and SAE 1117 were separated. These steels differed only .05 per cent in carbon content, a difference difficult to detect rapidly by any other means. In this instance the division was faced with a wartime critical shortage of steel for certain types of gears, and the comparator's quick sorting job singled out the type of steel needed. A threatened production line stoppage was averted.

2. Preventing a mix-up of metallic test bars used in inspection work.

3. Separating two types of automotive valves, also differing only slightly in chemical content or alloys. In this instance the valves were made for experimental engines when a mixup occurred and a nondestructive method was needed to sort them. As a result, the entire valve job did not have to be redone.

4. Separating a mix-up of 12,000 clutch levers, some made of SAE 1010 and others made of SAE 1020.

5. Detecting chills in castings, an important factor in quality control.

The GM Research comparator uses the principle of a thermocouple, but in an unusual way.

An ordinary thermocouple is a loop of two different materials. When one of the junctions of the metals is hot and the other cold, a small electric current flows through the loop.

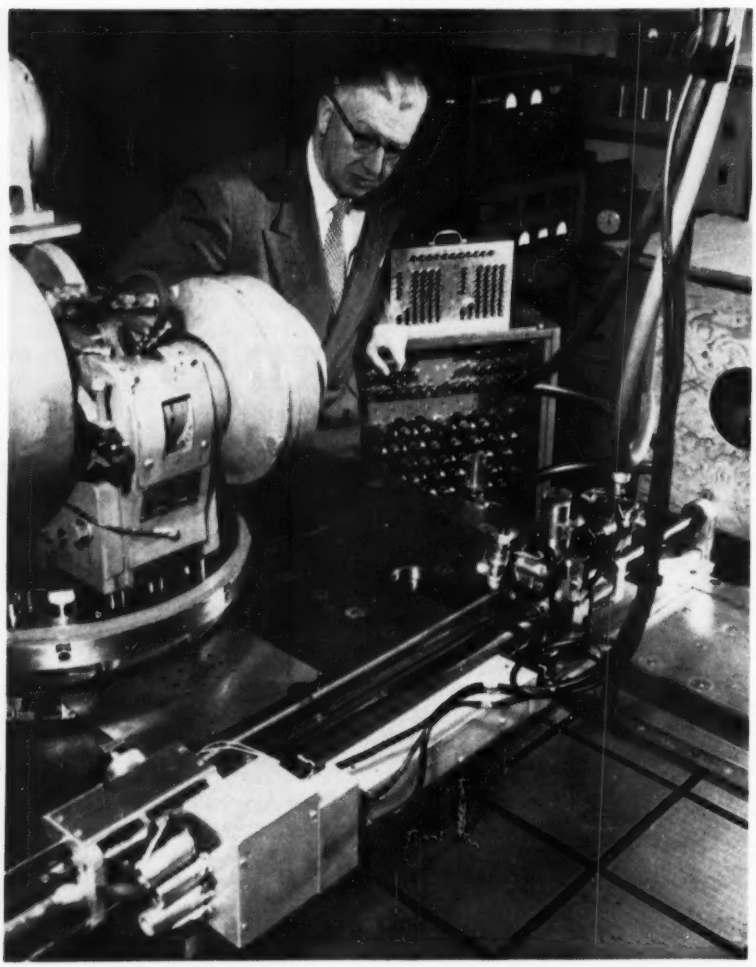
For example, if copper and iron wires are twisted together to make a closed circuit and one of the junctions is heated, an electric current flows through the circuit. Voltage generated depends on temperature differences between the junctions of the dissimilar wires.

Thus, thermocouples are used as laboratory thermometers because they measure wide temperature ranges very accurately, from low temperatures to the melting points of iron and copper wire, for instance.

The GM Research comparator's circuit also is a loop of two different metals. but the part being tested (clutch lever, valve, steel bar, etc.) forms part of the loop or circuit. The instrument's two probe tips are the hot and cold junctions where they touch the metal under test.

Since temperatures of the two junctions are kept constant, the

The latest thing in punch presses is this electronically controlled press, which receives directions from a digital computer.



What is an Engineer?

Man? Superman? Beast?

Read ENGINEERS AND IVORY TOWERS by Hardy Cross, Edited by Robert C. Goodpasture, Copyright by McGraw-Hill—$3.00.

Do you want to move the earth?

Read HOW TO OPERATE EXCAVATION EQUIPMENT by Herbert L. Nichols, Jr., published by North Castle Books—$1.50.

BOOK DEPARTMENT

TRIANGLE BOOK CO-OP

Evan J. Morris, Proprietor

412 College Avenue Sheldon Court

Serving Cornellians Since 1903

Fraternities Sororities

Attention

for

INVITATIONS

RUSHING BOOKS

SONG BOOKS

FRATERNITY PAPERS

Stop At The

Norton Printing Co.

317 E. State St.

Opposite the Strand Theatre

change in metallic composition of the part under test results in a voltage change that can be read on the instrument's meter.

Because the small difference in temperature between the two tips results in a small voltage, an amplifier is included in the circuit to make possible use of a quick response-time indicator to increase sensitivity.

Thus, the comparator can be adapted to most problems by selecting the right set of probe tips. Several sets of tips are available in different alloys of steel and other metals.

The usual method of choosing a set of tips is simply to try the sets and pick out the one that gives the best separation readings for sorting metals. For a particularly difficult separation of mixed parts, it is possible to make a special set of tips for the comparator.

The instrument is now being tested for measuring thickness of metallic plating or paint films, comparing the surface layer with a similar layer of known thickness. In this application it operates as an ordinary thermocouple, detecting temperature changes at the hot junction.

When measuring thickness of electrically non-conducting films, such as paints on metals, a thin sheet of copper and aluminum foil placed over the paint film completes the electrical circuit between the comparator's two probe tips.

Industry Hails Operations Research

"Operations Research," a new branch of applied science, first used in World War II for the solution of military problems, is now engaging the attention of industry.

According to Philip M. Morse, professor of physics at Massachusetts Institute of Technology, operations research is "the application of research techniques to the study of the operations of war and peace . . . (It) looks at what goes on when some team of men and equipment goes about doing its assigned job."

A typical operations research project can best be carried on by a team of workers having a variety of backgrounds. The technique can be used to attack the problem of people lined up to go past a service point, as in a cafeteria. Equations used to solve the problem employ symbols for such variables as rate of service, rate of arrivals, and probabilities as to the number of persons in line at any given time.

Similar equations can be established, Morse says, in solving problems involved in aircraft landing control, traffic movement, and machine maintenance.

During World War II operations research was used in such military assignments as setting up a "rate of search" for enemy vessels. The mathematical models devised for use in searching out enemy craft can be applied to such industrial and business situations as the assignment of sales effort.

Professor Morse concludes:

"In general, scientists and engineers have not been active in administering government or business . . . for the business of science is to understand, not to act. In operations research, however, the scientist and engineer can provide a better understanding of operational problems so administrative decisions can be made wisely."

Underwater Welding

(*Continued from page* 14)

an attempt to clarify the graphical presentation of these data.

Figure 5 shows the particle size distribution curves for welding underwater. From this it is seen that the particle size distribution curves for all of the untreated electrodes fall within the same narrow range. The particle size distribution curves for all of the electrodes coated with shellac and water glass are all coarser than those of the untreated electrodes. Paraffin and lacquer, on the other hand, shift the particle size distribution range to the right of the untreated electrode range, or toward a finer distribution.

Figure 6 shows the particle size distribution curves for above-water welding. In this type of welding the particle size distribution curves for all of the untreated electrodes as well as those waterproofed with shellac fall together within a narrow range. As was the situation with below-water welding, the water glass coated electrodes again had the coarsest particle size distribution. Similarly, the lacquer coated rods again had the finest particle size distribution.

A comparison between the two figures themselves reveals that welding underwater has the general effect of shifting all of the above-water particle size distribution curves to the right. It is thus apparent that underwater welding is characterized by a finer particle size distribution for all electrode-waterproofing coating combinations than is obtained in above-water welding .

The mechanism by which waterproofing agents determine the particle size distribution characteristics are not known. It is postulated that the vaporization of the coating during welding somehow changes the nature of the gaseous arc shield, thereby altering the mode of metal transfer through the arc.

Electrode Operating Characteristics

Any theoretical approach should be tempered by practical considerations. It is important to note the change in operating characteristics of each electrode when used underwater, and the further effect on these characteristics induced by the waterproofing materials.

No electrolytic corrosion was encountered in any tests using reverse polarity. This is not unusual, for the time of electrode immersion was never longer than ten seconds, and the electrode holder was not submerged. The E-6010 electrodes all spattered violently below-water. This was due to the original coating composition, and not polarity, since E-6011 electrodes, which also operated on reverse polarity, gave almost no spatter.

The E-6010 underwater welded beads were somewhat irregular. The electrode coating produced a gas which burned spasmodically at the water surface, obscuring the weld area. E-6011 electrodes were a considerable improvement, giving a low continuous bead which was comparable in appearance to welds made above-water. There was little difficulty maintaining an underwater arc with the E-6010 electrodes. E-6012 electrodes produced a high narrow bead of fair continu-

(*Continued on page* 48)

CRESCENT

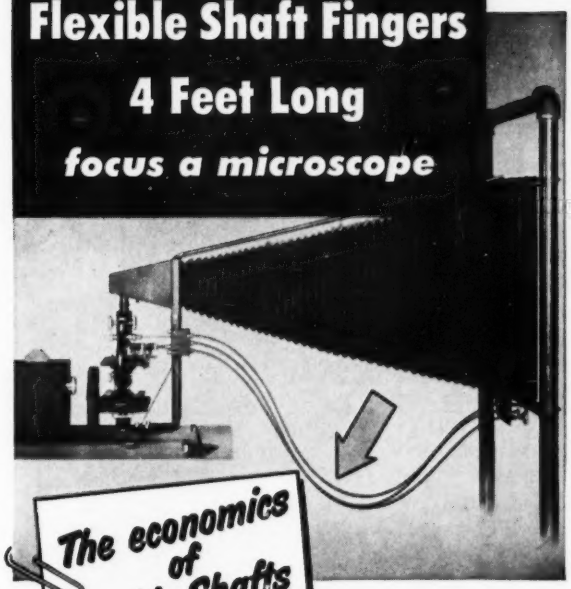
Insulated Wires and Cables

For more than 70 years CRESCENT Wires & Cables have played a leading role in the growth of the electrical industry. Pictured here are just a few of the many wires and cables made by CRESCENT.

CRESCENT INSULATED WIRE & CABLE CO.

TRENTON, N. J.

Flexible Shaft Fingers 4 Feet Long *focus a microscope*



The economics of Flexible Shafts

When the manufacturer of this microprojector wanted to provide a means of focusing the microscope from control knobs mounted 4 feet away, he used S.S.White flexible shafts. No other method offered the same simplicity and economy. As for sensitivity, the flexible shafts fully satisfied all requirements, because they are engineered and built to provide smooth, easy control over distances of 50 feet or more.

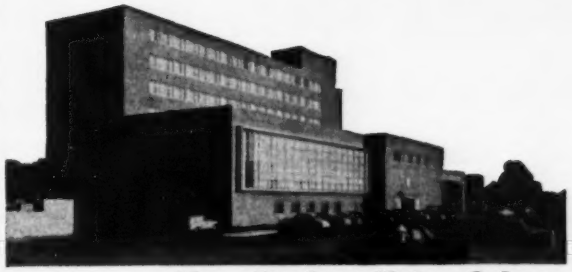
* * * *

Many of the problems you'll face in industry will involve the application of power drives and remote control with the emphasis on low cost. That's why it will pay you to become familiar with S.S.White flexible shafts, because these "Metal Muscles"® represent the low-cost way to transmit power and remote control.

SEND FOR THIS FREE FLEXIBLE SHAFT BOOKLET . . .

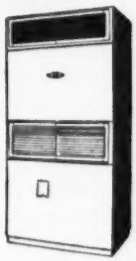
Bulletin 5008 contains basic flexible shaft data and facts and shows how to select and apply flexible shafts. Write for a copy.

THE S.S.White INDUSTRIAL DIVISION
DENTAL MFG. CO.
Dept. C, 10 East 40th St.
NEW YORK 16, N. Y.



New Student Union Selects Air Conditioning & Refrigeration

FRICK



This fine building of the Indiana University Medical Center, at Indianapolis, comprises apartments, guest rooms, dining halls, shops, swimming pools, etc.

Here both air conditioning and food service loads are handled by 13 Frick refrigerating machines, and a Frick unit air conditioner. Installation by Hayes Bros., Inc., Distributors at Indianapolis and South Bend. For that important cooling job of yours, specify Frick equipment: there's nothing to compare with it. Write now for Bul. 100 on "ECLIPSE" compressors.

The Frick Graduate Training Course in Refrigeration and Air Conditioning, operated over 30 years, offers a career in a growing industry.

DEPENDABLE REFRIGERATION SINCE 1882

FRICK CO.

WAYNESBORO, PENNA. U.S.A.

THE MONTH OF MAY AT THE NEW CAMPUS STORE BRINGS —

Lots of activity in SPORTS GOODS, MEN'S WEAR and THE CO-ED SHOP. Equipment for tennis, badminton, golf and swimming together with sports clothing for participants and spectators.

A big display of Cornell Steins and souvenirs in the GIFT DEPARTMENT for picnics beer parties, Spring Weekend and the end of the term.

And at the end of the month, the BOOK DEPARTMENT will be buying used textbooks for cash and you will all be able to better your financial statis.

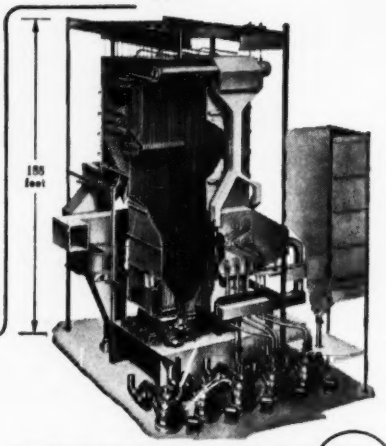
DROP IN OFTEN DURING MAY. IT'S CONVENIENT AND THERE IS SOMETHING NEW TO SEE EVERY TIME.

THE CORNELL CAMPUS STORE

Barnes Hall

POWER COSTS ARE WAY DOWN HERE

instead of way up here because ever since 1881, when Thomas A. Edison installed this B&W boiler in America's first central station on PEARL ST. in New York, B&W has committed men, machines and money to a fruitful, continuing search for better ways to make steam and get more energy from common fuels. Today's power boiler stands this high. It stands for power progress and the pledge to keep research and engineering first--to produce even more steam power at lower cost.



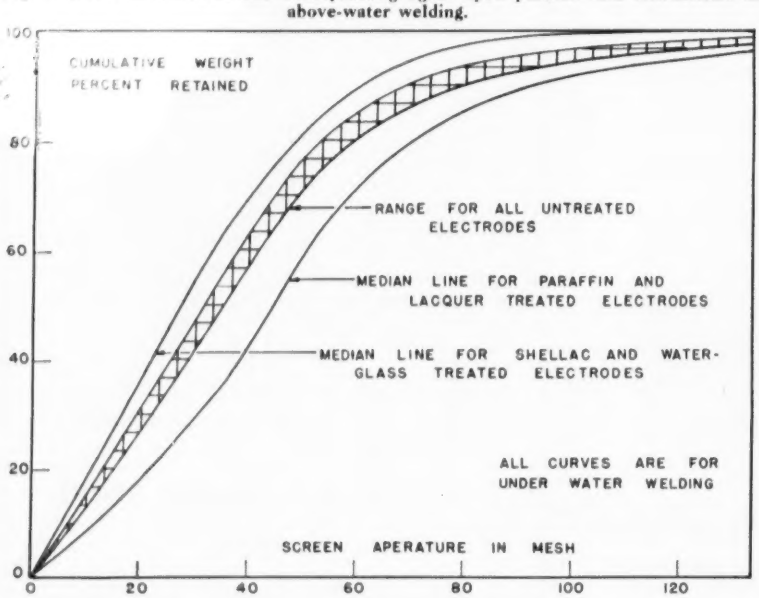
BABCOCK & WILCOX
BOILER DIVISION
G-647

(*Continued from page 46*)

ity. Neither the immersion nor the water-proofing coatings had a significant effect on the operating characteristics of the E-6012 rods. Variation in waterproofing coatings, however, did have an appreciable effect upon the welds made with the E-6013 electrodes. As a class they gave considerable spatter and a low wide bead with a slightly irregular surface. The E-6013 electrode ran much "hotter" underwater than it normally does above-water.

Electrodes which were not water-proofed were generally unsuitable for welding underwater. The extruded coatings chipped and pealed during underwater operation, and tended to scorch or burn unevenly as far as three inches up the rod. Arc maintenance was generally unaffected.

Fig. 6. Effect of electrode and waterproofing agent upon particle size distribution in above-water welding.



Shellac and water glass exhibited almost identical characteristics. Both materials improved bead continuity and ease of arc maintenance for all electrodes. Shellac markedly reduced the tendency for undercutting, which is often a serious problem in underwater welding. Waterglass had little effect on the undercutting tendencies of the electrodes. The lacquer did not improve the general quality of the weldments made with the untreated electrodes, but did cause an unusual peak-shaped bead. Paraffin seemed to have little effect on electrode operation and weld surface appearance.

In all cases, welding in still water is difficult. The primary problem is the formation of colloidal dispersions of carbon and filler metal particles which immediately cloud the weld area, thus impairing ob-

servation. Welds must be made cautiously because the arc is easily broken.

Summary

On the basis of this investigation the following six general conclusion may be drawn:

1. Underwater welding is characterized by a finer particle size distribution than is obtained in above-water welding for all electrode-waterproofing combinations.

2. The problem of current leakage through the coating is encountered in underwater welding. The magnitude of this leakage is in the probable range of 10-20%.

3. The specific electrode type and waterproofing agent used in underwater welding determines the characteristics attained.

4. Electrodes which have been waterproofed with the same agent show approximately the same barrel length and depth of penetration on above-water welding.

5. The variation in barrel length and depth of penetration with the type of waterproofing coating for a given electrode is greater for below-water welding than for above-water welding.

6. Water glass causes a coarse particle size distribution and lacquer causes a fine particle size distribution when used as waterproofing agents for all electrodes in both above and below-water welding.

Specifically, the E-6013 electrode with a waterproof coating of shellac was, observed to be superior to other combinations as to maximum depth of penetration and avoidance of undercutting.

The authors recognize their investigation is of limited scope, and as such is but an initial step forward in the direction of a better technical understanding of underwater metallic arc welding. Clearly, it is only through further research that we will ultimately be able to fully utilize this process in such fields as marine repair and minimization of post-welding distortion.

Bibliography

1. Sanders, H.; "Welders in Diving Suits," CORNELL ENGINEER, March, 1947.
2. Waugh, Roger C. and Eberlein, Otto P.; "Penetration Factors in Metallic Arc Welding," CORNELL ENGINEER, May, 1953.
3. Fast, J. D.; Polytech, Tijdsche, 7, page 217.

Synthetic Gems

(*Continued from page* 17)

the boule is allowed to cool within the furnace.

For the growth of titania crystals, this process is modified somewhat. A vibrator is used instead of a tapper on the hopper in order to have a constant flow of feed, thereby giving less strain to the crystal. A variable speed motor is attached to a worm gear and the pedestal is lowered automatically. Again, this would give the crystal less strain than to be hand-lowered as the corundum boules are. Since an oxidizing atmosphere is necessary for titania growth, the burner is constructed so that there are three orifices: an inner and outer oxygen layer with the hydrogen in the middle. This also gives two reaction zones; i.e. two oxygen-powder orifices.

Of the synthetic gem crystals, sapphire is the only one that has found widespread industrial use. Industrial sapphire has a Mohs hardness of 9. Therefore, only the diamond, with Mohs hardness of 10, can be used for shaping it. An inexpensive flame-polishing operation is frequently used if the crystal is rod-shaped.

Synthetic Minerals as Gems

Top billing goes to the titania jewels whose sparkling brilliancy outdazzles diamonds. The index of refraction (2.605) is greater than that of the diamond and the dispersion is six times greater. Since the colorless rutile is not an imitation of a natural stone as are the other synthetics, it is probably the first truly new gem since the advent of modern jewelry. It resembles a high-grade Cape or pale yellow diamond.

When the National Lead Company began experimenting with titanium dioxide in 1945, they had nothing rarer in mind than paint pigments, hoping to find a way to make white paint whiter. When their experiments led to this brilliant new jewel, they found themselves overnight in the gem business. They hired New York's London-born Reginald C. Miller as gemcutter. Titania made its debut in late 1949 in a modified round brilliant cut that best shows off the fire of the stone.

Another gem-making triumph is the production of synthetic star rubies and star sapphires. There are less than five hundred good natural star rubies in existence, these owned by Eastern princes and museums. These natural stones have the same chemical composition and crystal structure as ordinary rubies or sapphires, but, in addition, contain numerous microscopic needles of titania scattered through the body of the crystal in a symmetrical, three-directional pattern. Incident light from a point source is scattered by these needles to give rise to the six-rayed star.

Linde Air Products was the first company to produce synthetic star stones. The Linde star ruby and sapphire synthetics were first shown in the great precious gem room of the American Museum of Natural History in 1947. Wrote *Time* magazine: ". . . besides the synthetics, many of the natural stones in the museum's collection looked pallid . . ." Equally impressive is the fact that the Linde synthetic star costs only $20 a carat.

Today, "cooked jewels" are filling the gap between costume jewelry and rare precious stones. Four-fifths of all the stones of educational and fraternal jewelry are synthetic. These jewels have all the virtues of heirloom gems—except rarity and price.

Civil Defense

(*Continued from page* 19)

most feasible routes leading to the probable damage and to make plans for the circulation, regulation, and control of emergency traffic, (2) to develop operational plans for utilizing the community's manpower and road equipment to clear clogged streets and highways, (3) to repair and maintain adequate water, power, gas, sewer and refuse collection service, (4) to install and operate the special items of equipment FCDA has stockpiled near target areas, and (5) to perform other specialized engineering tasks. An understanding of these activities will make everyone with engineering training better equipped to engage in civil defense work on short notice to help meet whatever war or other emergency situation may arise.

School of Chemical Engineering

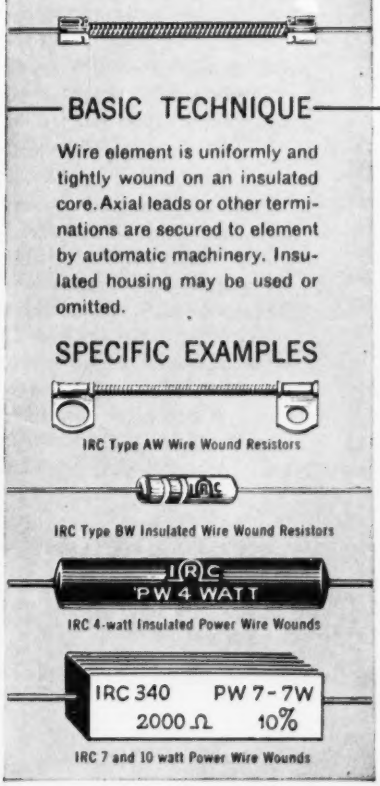
1. Morrow, R.
2. Campbell, K.
3. Schadler, H.
4. Eberlein, O.
5. Gregg, J., Prof.
6. Klye, P., Prof.
7. Winding, C., Prof.
8. Mason, C., Prof.
9. Thorpe, R., Prof.
10. Kelly, R.
11. Blackwood, J.
12. Falk, C.
13. Gazley, R.
14. Heicklen, J.
15. Lowenthal, M.
16. Stevens, R.
17. Karmel, K.
18. Gryson, J.
19. Freyer, R.
20. Johnson, W.
21. Waugh, R.
22. Banker, R.
23. Eccles, R.
24. Jones, J.
25. Makosky, P.
26. Dardin, V.
27. Lord, K.
28. Arlook, R.
29. Inskeep, M.
30. Sperry, W.
31. Van Soye, C.
32. Reed, R.
33. Masmuto, S.
34. Baumann, J.
35. Ertel, E. R.
36. Beardsley, J.
37. Cattarulla, E.
38. Williams, P.

CLASS OF 1954

Department of Engineering Physics

1. Falk, D. S.
2. Smith, L., Director
3. Hartman, P. L., Prof.
4. Jewell, W.
5. Pottasch, S.
6. Rossin, A. D.
7. Haibt, L.
8. Reidel, E. P.
9. Amey, H.
10. Glasgal, R.
11. Whalen, P.
12. Stengle, G.
13. Mange, A.
14. Halberstadt, R.
15. Rosenau, M.
16. Lynch, R.
17. Clough, S. A.
18. Hoeppel, R.
19. Haas, C. W.
20. McIlroy, M. D.
21. Meyerhofer, D.
22. Button, J.
23. Stevens, R.
24. Kellner, G.

Precision, high-speed winding equipment for IRC elements


BASIC TECHNIQUE
Wire element is uniformly and tightly wound on an insulated core. Axial leads or other terminations are secured to element by automatic machinery. Insulated housing may be used or omitted.
SPECIFIC EXAMPLES
IRC Type AW Wire Wound Resistors
IRC Type BW Insulated Wire Wound Resistors
IRC
PW 4 WATT
IRC 4-watt Insulated Power Wire Wounds
IRC 340 PW 7-7W
2000 Ω 10%
IRC 7 and 10 watt Power Wire Wounds

IRC WINDING SKILL OFFERS REALISTIC SAVINGS TO INDUSTRY

. . . another reason why engineers specify IRC Resistors

Savings in the initial cost and assembly of component parts are an increasingly important factor to electronic engineers. That's why they depend upon IRC for their resistor requirements. IRC's mastery of winding wire elements—dating back more than 25 years—today provides a wide variety of unique units that offer realistic possibilities for savings.

IRC

Wherever the Circuit Says

INTERNATIONAL RESISTANCE CO.

401 N. Broad St., Phila. 8, Pa.

In Canada: International Resistance Co., Toronto, Licensee

Cable specifications and s

THE POSSIBILITY of fires and personal injury connected with distribution of electricity by means of wires and cables, means that such wires must conform to certain minimum requirements. This was recognized in 1881 by New York's Board of Fire Underwriters, when it outlawed the use of bare or uncovered wires for the distribution of electricity in buildings and adopted "A standard for Electric Light Wires, Lamps, etc." This standard contained five rules, one for the conductivity of the conductor, one describing the insulation and the other three dealing with installation of electrical equipment. The rules for the conductor and insulation read as follows:

"1. Wires to have 50 percent excess conductivity above the amount calculated as necessary for the number of lights to be supplied by the wire.

"2. Wires to be thoroughly insulated and doubly coated with some insulating material." These two rules constitute the first effort to set up limits or to be specific with regard to insulated wire for power distribution. In other words, they constitute the first specification for insulated wires and cables for the distribution of electricity.

Historically, the next important concept concerning the covering was that of its insulating properties or its ability to confine the potential to the conductor. This was established by setting up minimum thickness of the insulation for the various conductor sizes and providing requirements for test voltages and insulation resistances for these thicknesses. Such requirements were included for the first time in the National Electrical Code for 1899. The insulation thickness for rubber insulation for a given voltage service and conductor size was essentially the same as that used today, namely, 3/64" on size 14 Awg. for 600 volt cable. The test voltage requirement was 3000 volts per 1/64" of insulation thickness, after immersion in water, distinctly more severe than present requirements. The insulation resistance requirement for 600 volt wire was 100 megohms per mile. The 1899 code also contained requirements for the dimensions of copper conductors and for tinning of conductors for rubber insulated cables. There appeared here, for the first time, a requirement for braids.

This was followed by the establishment of minimum requirements for tensile strength and elongation of rubber insulations in the original specification of the Association of American Railroads in 1905 and Underwriters' Laboratories, Inc. Standard about 1911. The 1905 specification of A.A.R. also included requirements for the chemical composition of thirty percent rubber insulation. These requirements were later adopted by Underwriters' Laboratories, Inc. and the American Society for Testing Materials.

Although aging requirements for rubber insulation were proposed in connection with the first specification of the Association of American Railroads, it was not until 1933 issue of Specification D 27 of the American Society of Testing Materials that aging became an industry specification requirement for rubber insulations. The requirements for heat-resisting rubber were included for the first time in A.S.T.M. specifications for 1937. The requirements for moisture resisting rubber insulation were established about this time. The requirements for Polyvinyl Chloride and Laytex insulations were established in the National Electrical Code of 1940. Since then the requirements for the various synthetic rubber insulations have been set up.

During this period, other types of insulations such as paper, varnished cambric and asbestos and many types of sheaths and coverings for wires and cables were developed. More detailed requirements for conductors were also established. There are today, therefore, a wide variety of cables for use in the distribution of electricity for power and control purposes.

Practically every element of these wires and cables is covered by detailed specification requirements or standards. There are specifications for bare or uninsulated wires and cables, for covered wires, such as weatherproof wire and all insulated wires and cables, regardless of the type of insulation or coverings. Such specifications cover, in detail, the construction and requirements for the conductor, the thickness, physical, aging, electrical, moisture

For reprints of these pages write to address below.

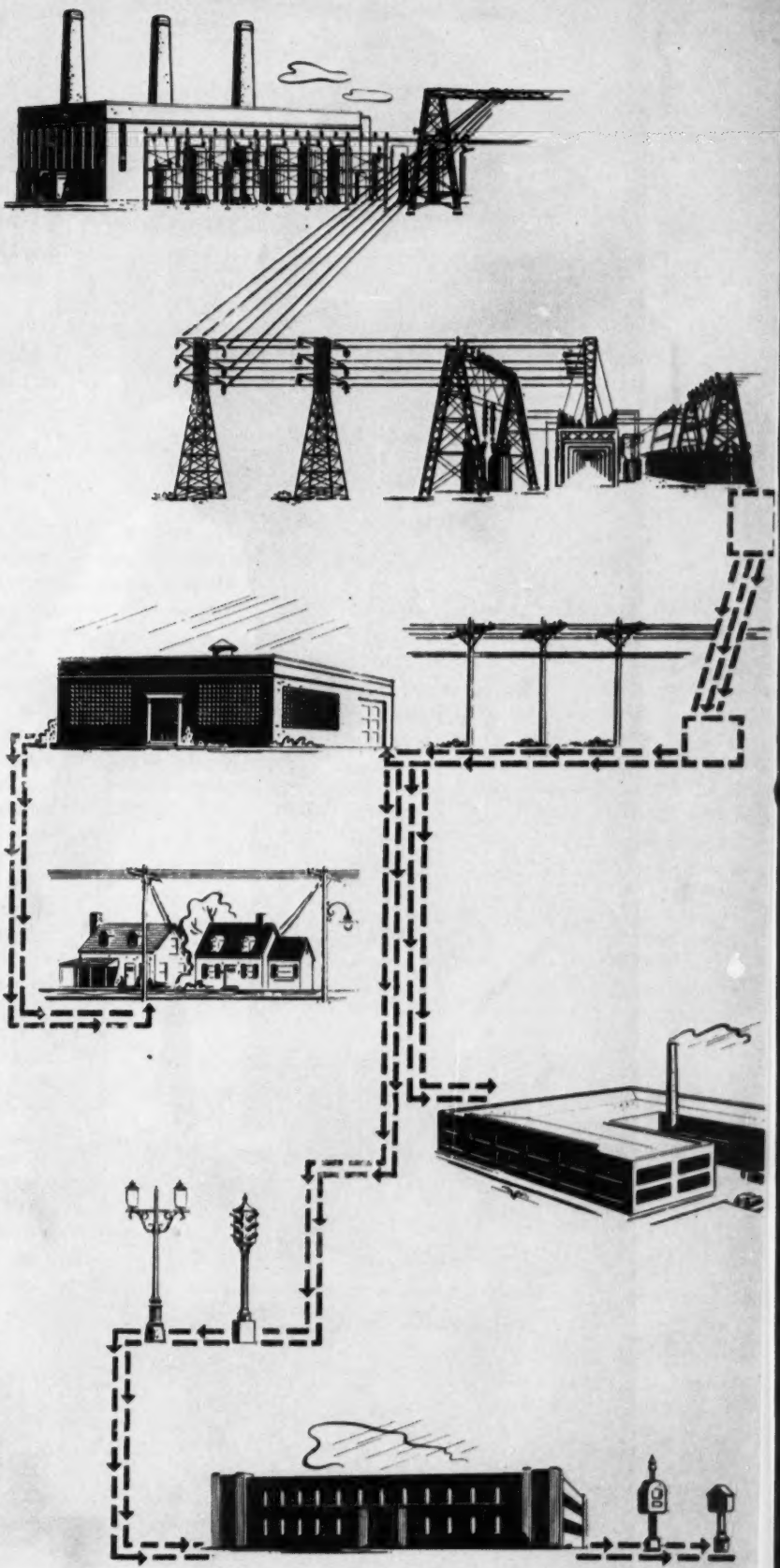
UNITED STATES RUBBER COMPANY

Electrical Wire and Cable Department • Rockefeller Center • New York 20, N. Y.

standards

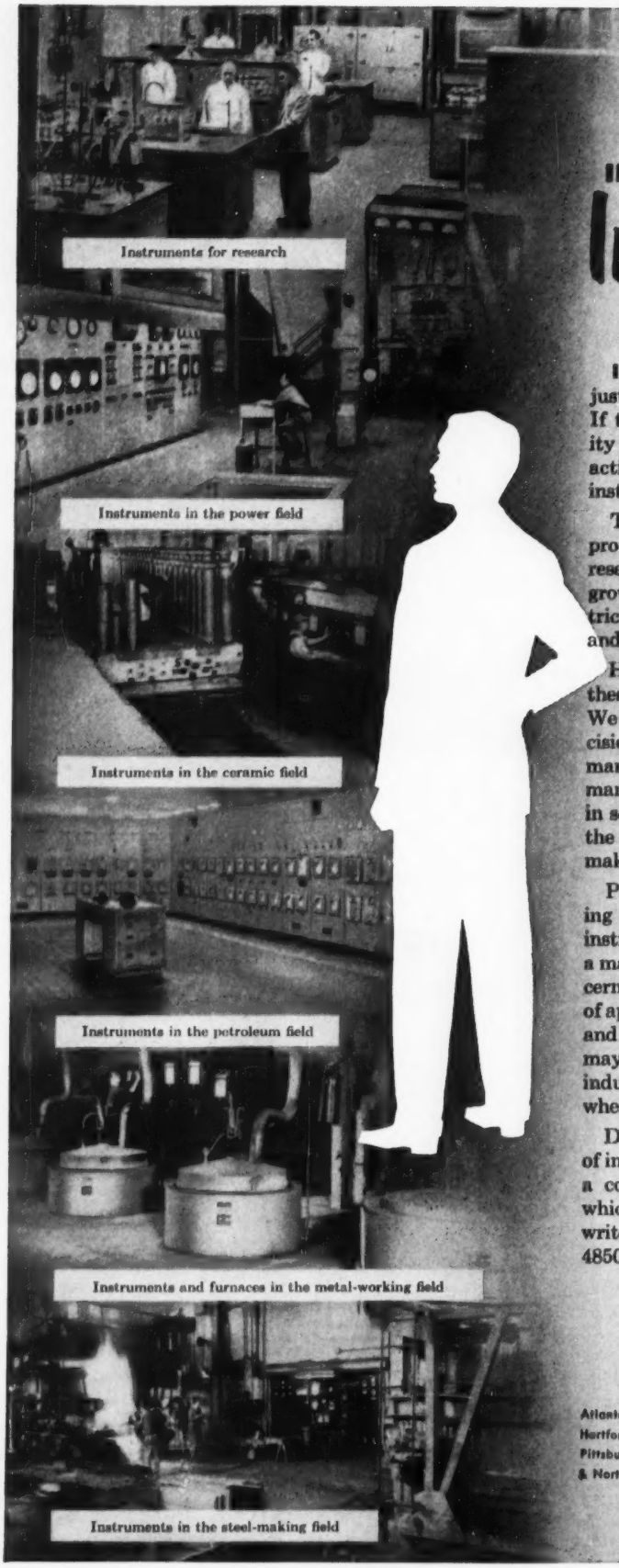
and ozone resisting properties of the insulation, the construction details of the cables and the thickness and other properties of the covering or sheath. These specifications are issued by literally hundreds of manufacturing organizations, municipalities, railroads, utilities, government agencies, etc. They may differ only slightly but significantly, in certain details, thus making it necessary to run many wires on special orders. The wire and cable industry is thus obviously specification conscious. In fact, it is probably true that all types of wires and cables used today are more completely covered by specifications than any other class of commercial products of equal complexity.

Specifications have thus become a necessary and important part of the wire and cable industry. When properly prepared on the basis of sound engineering, information and manufacturing practices, they provide for durable, economical and safe cables for any particular application. They describe the item in a clear and concise manner that can be readily understood by any one familiar with the industry. They form the basis for contracts between cable users and cable manufacturers, and eliminate or minimize any questions that might arise concerning the construction or quality of the cable under consideration. A working knowledge of wire and cable specifications is essential for those interested in the development, manufacture and use of wires and cables.



US RUBBER

No. 5 in a Series


Instruments for research
Instruments in the power field
Instruments in the ceramic field
Instruments in the petroleum field
Instruments and furnaces in the metal-working field
Instruments in the steel-making field

TAKE YOUR PLACE

IN A FIELD WITH A FUTURE . . .

Instrumentation

Is there still some question in your mind as to just where you fit into the engineering picture? If there is . . . and you want to apply your ability to a wide scope of industrial and scientific activity . . . consider the expanding field of instrumentation.

The increasing use of instruments to control production lines . . . to test products . . . to solve research problems is reflected in the spectacular growth of the field. In recent years, sales of electrical measuring instruments have risen 455% and sales of scientific instruments 655%.

Here at Leeds & Northrup, we help to meet these demands for more and better instrumentation. We are a leading supplier of automatic, high precision, balance-type electrical instruments for many segments of industry. Our automatic and manual laboratory-type instruments for the worker in science and research are recognized throughout the world. In addition, we are among the leading makers of furnaces for heat treating.

Perhaps your opportunity is in our sales engineering division—helping to analyze and to solve the instrumentation problems of our customers. Or, as a market development engineer, you would be concerned with fitting L&N instruments to new groups of applications. Your interest may lie in the design and manufacturing of L&N products. If so, you may qualify for an opening in product engineering, industrial engineering, research, inspection or elsewhere among our 3000 people.

Decide now to investigate your place in the field of instrumentation. Ask your placement officer for a copy of our booklet, "Career Opportunities" which describes the highlights about L&N. Or, write to the Industrial Relations Department, 4850 Stenton Ave., Philadelphia 44, Pa.

LEEDS [N] **NORTHRUP**

instruments *automatic controls* • *furnaces*

Atlanta • Boston • Buffalo • Chicago • Cincinnati • Cleveland • Detroit
Hartford • Houston • Los Angeles • Milwaukee • New York • Philadelphia
Pittsburgh • San Francisco • Seattle • St. Louis • Tulsa • Integra, Leeds & Northrup, Ltd., Birmingham, Eng.

STRESS and STRAIN...

A local policeman stopped his squad car and hailed an inebriated gentleman who was making his dubious way down the street.

"Hey, you!" he shouted, "where are you going in that condition?"

"Gonna work," mumbled the drunk.

"Oh yeah," growled the officer, "what kind of work can you do in the shape that you're in?"

"Minin'."

"Minin' what?" persisted the officer of the law.

"Minin' my own damn business!" the other snapped. "Why don't you do the same?"

* * *

Two little girls were discussing their families. "Why does your grandmother read the Bible so much?" asked one. The other replied, "I guess she's cramming for her finals."

* * *

A spinster was shocked by the language used by workmen repairing a telephone near her home, so she wrote the company.

The foreman was requested to make a report. The report read as follows:

"Me and Spike were on this job. I was up on the pole and I accidentally let the hot lead fall on Spike—right down his neck. Then Spike looked up at me and said, 'Really, Harry, you should be more careful'."

* * *

Coed: What wonderfully developed arms you have!

Guard: Yeah, I'm on the squad. By the way, have you ever been on the track team?

* * *

Student: "Could you help me with this problem?"

Professor: "I could, but I don't think it would be quite right."

Student: "Well, take a shot at it anyway."

"The Irish aren't so tough."

"How come?"

"Me and my brother and the two guys across the alley almost licked one last night."

* * *

Salesgirl at perfume counter to Cornell Coed: "Just a word of advice; don't use this stuff if you're only bluffing."

* * *

A married couple checked into a hotel and, after cleaning up, forgot to turn off the faucets in the tub. A short time afterwards, the guest in the room directly under them opened the window and stuck out his head.

"Turn off that water," he screamed. "What the !$&#?!# is the matter with you?"

"Stop your swearing," the first returned. "I've got a lady up here."

"And what do you think I have down here—a duck?"

* * *

A woman approached the pearly gates and spoke to St. Peter, "Do you know if my husband is here? His name is Smith."

"Lady, we have lots of Smiths. You have to be more specific."

"Joe Smith."

"Lotsa those, too. You'll have to have more identification."

"Well, he said before he died that if I was ever untrue to him, he would turn over in his grave."

"Oh, you mean 'Pinwheel' Smith."

* * *

The most observant person was the historian who noticed that Lady Godiva had a horse with her.

* * *

A Southern election board was counting the ballots when a Republican ticket showed up. Not finding anything wrong with it, the board put it aside as suspicious only. After several hours a second Republican ballot showed up. This was going too far. The judge said, "The son-of-a-gun voted twice. Throw 'em both out."

A man was perched atop a building in Chattanooga and it looked like another attempted suicide. A policeman made his way to the building's roof to persuade him not to jump.

"Think of your maw and family," pleaded the cop.

"Ain't got any."

"Well, think of your girl-friend."

"I hate women!"

"All right," said the policeman desperately, "Think of Robert E. Lee."

"Who's he?"

"Jump, you damn Yankee!"

* * *

Engineering Prof.: "Why aren't you taking notes?"

Student: "I don't have to. I've got my grandfather's."

* * *

The drunk weaved his way to his car, opened the rear door and climbed in.

"Here there," cried a cop passing by. "You're in no condition to drive."

"Oh, shtop botherin' peashful citizens. If you want to do something ushful, whynt you catch the guy who shtole my shteering wheel?"

* * *

"Your ear is bleeding. What happened?"

"I bit myself."

"Silly! How could you bite yourself on the ear?"

"I stood on a chair."

* * *

Friend to forlorn engineer: "Buck up, old man! Why don't you drown your sorrow?"

"I can't. My E.E. teacher is stronger than I am."

* * *

K.D.: "What does the Chaplain of Congress do?"

Sig: "He just gets up on the platform, takes a look at the senators and representatives, and prays for the country."

Index to Volume 19

Articles

	No.	Page
AERIAL PHOTOGRAMMETRY Damon G. Douglas, CE '56	3	23
ALCOHOL FROM ETHYLENE Lavonne Olson, ChemE '57	2	13
ARTILLERY OF THE ANCIENTS Robert Kantor, EP '57	3	15
THE AUTOMATIC SPRINKLER Robert Z. Fowler, EE '54	7	15
CHEMICAL & METALLURGICAL ENGINEERING F. H. Rhodes, Director	4	18
CIVIL ENGINEERING N. A. Christensen, Director	4	16
THE COLLEGE OF ARCHITECTURE T. W. Mackesey, Dean	4	22
CONTROL OF ATOMIC ENERGY John F. Ahearne, EP '57	5	13
THE DEVELOPMENT OF CORNELL'S ENGINEERING COLLEGE S. C. Hollister, Dean	4	9
THE DIVINING ROD Edwin Leventhal, EP '56	1	17
ELECTRICAL ENGINEERING C. R. Burrows, Director	4	12
ENGINEERING COUNCIL David Scheraga, ME '54	5	27
ENGINEERING PHYSICS L. P. Smith, Director	4	20
ENGINEERS' DAY—PICTURE BRIEF	8	28
ENGINEERS IN CIVIL DEFENSE—I	7	11
ENGINEERS IN CIVIL DEFENSE—II Howard C. Young, ME '19	8	18
THE ETHER-DRIFT EXPERIMENT Arthur H. Vaughan, EP '57	6	11
THE EVENTFUL LIFE OF THE TECHNICAL EDITOR Howard J. Sanders, ChemE '47	5	16
EXTRACURRICULAR ACTIVITIES Lavonne Olson, ChemE '57	4	30
FIFTY YEARS OF FLIGHT Janice Button, EP '54 Richard Brandenburg, EP '58	3	17
FREE-MOLECULE FLOW Marvin Litvak, EP '56	6	15
GLASS FIBERS Thomas Reed, ME '56	1	13
INORGANIC PAINT PIGMENTS Felix Rosengarten, ChemE '57	2	16
MECHANICAL ENGINEERING Harry J. Loberg, Director	4	14
METAL CERAMIC COMPOSITES John F. Schmutz, ChemE '55	2	20
SOME OBSERVATIONS CONCERNING THE COLLEGITRON Thomas Reed, ME '56	4	24
OUT OF PHASE Herbert Spirer, EP '51	4	49
PATENT LAW Joel Max, EP '57	1	21
ROCKET RESEARCH Richard Brandenburg, EP '58	5	19
SYNTHETIC GEMS Lavonne Olson, ChemE '57	8	15
UNDERWATER METALLIC ARC WELDING Otto P. Eberlein, MetE '54 Roger C. Waugh, MetE '54	8	11
WATER UTILITY MANAGEMENT James Symons, CE '54	6	19
WHAT'S IN STORE FOR THE CORNELL ENGINEERING GRADUATE? John F. McManus, CE '36, Assistant to the Dean	4	11
WVBR—PICTURE BRIEF	7	24

Authors

Ahearne, John F., EP '57	5	13
Brandenburg Richard, EP '58	3,5	17,19
Burrows, C. R., Director of EE School	4	12
Button, Janice, EP '54	3	17
Christensen, N. A., Director of CE School	4	16
Douglas, Damon G., CE '56	3	23
Eberlein, Otto P., MetE '54	8	11
Fowler, Robert Z., EE '54	7	15
Hollister, Dean S. C.	4	9
Kantor, Robert H., EP '57	3	15
Leventhal, Edwin, EP '56	1	17
Litvak, Marvin, EP '56	6	15
Loberg, Harry J., Director of ME School	4	14
Mackesey, Dean T. W.	4	22
Max, Joel, EP '57	1	21
McManus, John F., CE '36	4	11
Olson, Lavonne, ChemE '57	2,4,8	13 30,15
Reed, Thomas, ME '56	1,4	13,24
Rhodes, F. H., Director of ChemE School	4	18
Rosengarten, Felix, ChemE '57	2	16
Sanders, Howard J., ChemE '47	5	16
Scheraga, Dave, ME '54	5	27
Schmutz, John F., ChemE '55	2	20
Smith, L. P., Director of EP Department	4	20
Spirer, Herbert, EP '51	4	49
Symons, James, CE '54	6	19
Vaughan, Arthur H., EP '57	6	11
Waugh, Roger C., ChemE '54	8	11
Young, Howard C., ME '19	7,8	11,18

Personalities

Brophy, Jack, ME '54	5	25
Conway, Dick, ME '54	5	25
Smith, Culver, University Employment Counselor	1	35
Smith, Prof. Julian	7	23
Tracy, Thomas, ME '31	3	37

PHOTOGRAPHY AT WORK—No. 7 in a Kodak Series

Photography reads the meters *2500 an hour!*

Dial a call—an accurate register counts it—then each month photography records the total, precisely right, ready for correct billing.

TWENTY-FOUR hours a day, hundreds of thousands of dial phones click their demands in many central exchanges of the New York Telephone Company.

Little meters keep careful tally of the calls. Then the night before each bill is dated, photography reads the up-to-the-minute totals in a fraction of the time it could be done in any other way. Here is an idea that offers businesses everywhere simplification in copying readings on meters, dials or other recording instrumentation.

Photography fits this task especially well for two reasons. It is lightning fast. It can't make a mistake.

This is another example of the ways photography saves time, cuts costs, reduces error, improves output. In large businesses—small businesses—photography can do big jobs. In fact, today so many new applications of photography exist that graduates in the physical sciences and in engineering find them valuable tools in their new occupations. Other graduates—together with returning servicemen—have been led to find positions with the Eastman Kodak Company.

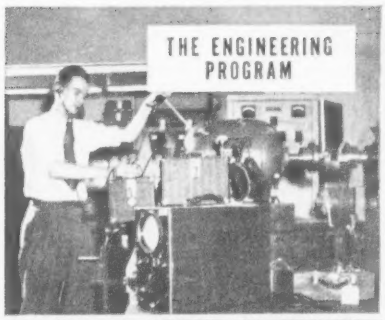
If you are interested, write to Business and Technical Personnel Dept., Eastman Kodak Company, Rochester 4, N. Y.

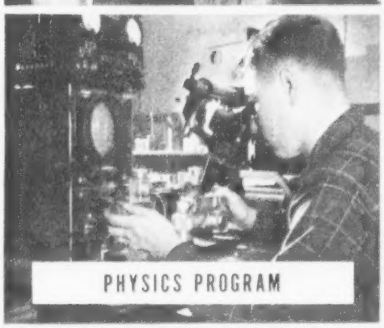
Eastman Kodak Company
Rochester 4, N. Y.

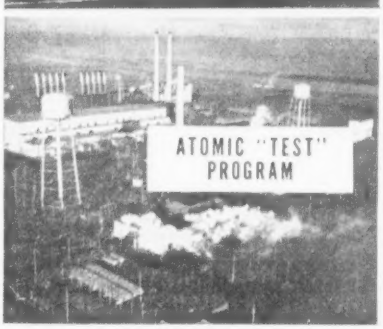
At New York Telephone Company exchanges a unique camera records the dial message register readings—up to 25 at a clip—saving countless man-hours of labor, assuring utmost accuracy and at the same time providing a permanent record.

Kodak
TRADE-MARK

10 ways to build a successful career







Few companies can offer as broad a range of career opportunities as General Electric. Whether a young man is interested in science or engineering, physics or chemistry, electronics or atomic energy, plastics or air conditioning, finance or sales, employee relations or advertising, marketing or metallurgy—he can find a satisfying, rewarding career.

The development programs shown here are "open doorways" that lead to highly successful careers in a Company where big and important jobs are being done, and where young people of vision and courage are needed to help do them.

If you are interested in building a G-E career after graduation see your college placement officer, or write:

COLLEGE EDITOR
DEPT. 2-123
GENERAL ELECTRIC CO.
SCHENECTADY 5, N. Y.

GENERAL ELECTRIC